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Crowdsourcing in Kazakhstan's higher education in the system of dual education as predictor of universal competencies

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ABSTRACT

The rapid transformation of professional competencies and the emergence of new professions every 3-5 years have accentuated the quest for effective means to facilitate the process of predicting future universal competencies among university graduates. An empirical study was conducted in three stages: organizational, investigative, and analytical. The crowdsourcing process algorithm comprised information gathering, idea generation, filtering, and voting. The findings suggest the feasibility of applying crowdsourced forecasting in the educational sector, where a clear trend towards alignment with real sectors of the economy and constantly changing market business environment conditions is evident. Calculations revealed that consensus decision-making was achieved regarding competencies such as 3D modeling and computer graphics, multilingualism, emotional intelligence, project management competencies, legal literacy, neural networks and big data, intercultural communication, digital competencies, export potential of the agricultural sector, logistics outsourcing, systems thinking, virtual reality competencies, artificial intelligence proficiency, analytics, and critical thinking, as confirmed by the analysis of variance. Forecasts indicated a predominance of subject-specific competencies associated with the growing volatility of the Kazakhstani labor market. The formulated profile of future universal competency development serves as an additional guideline in the development of educational programs (EPs) in professional training directions. Modified crowdsourcing design and methodology for measuring results can be utilized or adapted for addressing other challenges facing the higher education system that require feedback.

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1. INTRODUCTION

Global industrial and innovation-driven development, alongside the rapid transformation of the labor market, necessitates the training of a new generation of professionals [1]. The national economy increasingly requires human resources whose profiles are aligned with universal competencies that correspond to constantly evolving demands, innovative behavior, and the application of cutting-edge technologies [2]. In this context, the issue of refining approaches to forecasting future professionally relevant universal competencies within the higher education system has acquired strategic significance.

International experience suggests that, under current conditions, crowdsourcing technologies represent one of the most promising tools. These can be employed as an additional intellectual resource for gathering market data and generating market-oriented forecasts by harnessing the collective intelligence of stakeholders through crowdsourcing mechanisms [3]. However, many experts agree that there remains a lack of understanding regarding the conceptualization of crowdsourcing as a forecasting predictor within practical educational policy. This is largely due to a deficit of empirical studies on the management of integration processes involving crowdsourcing and collaborative forecasting mechanisms [4], [5], as well as an underdeveloped theoretical and methodological framework and a lack of robust tools for measuring the outcomes of crowdsourced forecasts [6].

Therefore, the aim of this study was to utilize crowdsourcing to identify universal competencies in various professional training fields that will be in demand in the future labor market. Based on the research aim, three objectives have been identified: to modify the design and methodology of conducting crowdsourcing for forecasting within the educational segment; to assess the degree of alignment of the competencies being developed among future specialists with the labor market requirements within existing educational programs (EPs) in Kazakhstani universities across various training directions; and to identify universal competencies across professional training fields that will be in demand in the future labor market. Thus, the hypothesis is: the verification of the results obtained from crowdsourced forecasting through comparative analysis will enable the determination of consensus decision-making among social groups.

In addressing the aforementioned gaps, this study contributes to the field by demonstrating how, within the framework of crowdsourcing, collaborative forecasting and the collective intelligence of stakeholders can be harnessed to define the developmental profile of universal competencies for future professionals. It also illustrates how crowdsourcing mechanisms can enhance and sustain this process. The proposed mixed-method (quantitative-qualitative) approach to measuring crowdsourcing integrates the strengths of two analytical paradigms: the quantitative assessment of labor resource volume within the economy, and the qualitative transformation of the competency set within professional domains. Moreover, the developed diagnostic toolkit has enabled the effective identification of a crowdsourced consensus forecast among representatives from various tiers of professional stratification.

2. LITERATURE REVIEW

Interest in crowdsourcing as a phenomenon, driven by processes of internationalization and globalization, is observed across various spheres of human activity, including industry, entrepreneurship, healthcare, and education. Crowdsourcing finds its broadest application in marketing for product beta testing [7], market research [8], and gathering fresh and innovative ideas and proposals [9]. Consumers have the opportunity to express their needs and suggest improvements to existing products [10]. There is evidence that user-generated content on crowdsourcing platforms of financial information aids investors in mitigating bias in traditional stock research, thereby better processing news in earnings announcements [11]. To incentivize and reward participants, a crowdsourcing platform combined with blockchain technology has been developed, allowing for incentives without the intervention of intermediary software and brokers [12].

Crowdsourcing fosters participation and collaboration between governments and citizens [13]. Although expert ratings remain a dominant approach in managerial structures, mass voting enhances citizens' trust in municipal society and encourages their involvement [14]. There are compelling examples of scientists utilizing crowdsourcing to refine or satisfy their need for specific knowledge from the community. For instance, psychologists and sociologists are increasingly transferring experiments traditionally conducted in experimental laboratories to crowdsourcing platforms, incorporating clustering algorithms with human involvement [15]. The effectiveness of crowdsourcing in enhancing the quality of cultural heritage metadata has been demonstrated. Through automatic analysis and feature extraction from annotations, along with crowdsourcing services, there is an excellent opportunity for scaling and improving metadata of digital cultural content, simultaneously engaging and enhancing participants' knowledge about cultural heritage objects [16]. In this context, crowdsourcing is considered a driving force of open science based on citizen participation and educational learning [17].

Crowdsourcing has demonstrated its immense potential in the field of education [18]. Crowdsourcing in education is not merely seen as task delegation to the crowd but as a form of innovation that, through idea generation and diverse opinions, provides alternative innovations beneficial to the educational segment [19]. Mass open online courses (MOOCs) and open innovations serve as remarkable examples of innovative crowdsourcing forms in education [20]. These digital platforms provide access to a broader range of students, including working professionals, caregivers, individuals with disabilities, and older learners. This shift significantly democratizes education, ensuring greater inclusivity and accessibility [21].

International researchers' experiences indicate that the use of crowdsourcing enhances student interaction and increases the accuracy and quality of education [22], not only due to its informational value

but also because of the social and entertaining activity facilitated by the gamification of crowdsourcing [23]. Researchers conclude that crowdsourcing is utilized and beneficial in education through four methods: creating educational content, providing practical experience, facilitating the exchange of additional knowledge, and enhancing feedback [24]. Depending on the goals within higher education, six main crowdsourcing models are considered most suitable: crowdteaching, crowdlearning, crowd-funding, crowdtuition, crowdvoting, and crowdsensing [25]. These broad, innovative crowdsourcing models are evident in various applied research projects in the field of higher professional education.

For instance, crowdsourcing has been used for collaborative assessment and processing of a large number of tasks [26], as well as in evaluating multiple-choice questions [27]. In other examples, crowdsourcing has been applied for joint development by teachers of high-quality, large-scale examination questions [28] and in creating joint university-industry projects [29]. A crowdsourcing project aimed at compiling a catalog of educational technologies for teaching and learning, initiated in the Republic of Ireland, demonstrated that the use of crowdsourcing led to an exponential increase in the scientific value of the developed catalog and that a significant number of people have already utilized it, created as a result of crowdsourcing activities [30]. Crowdsourcing has proven its effectiveness in interdisciplinary student learning [31], in improving translation skills and training qualified translators [32], in addressing real-world business challenges in management education [33], and in studying STEM disciplines beyond the classroom [34], among others. Remarkably, this method of learning contributes to the formation of educational experience among future professionals not by providing access to ready-made knowledge resources but through the direct active participation of students in the process of generating knowledge, thus enhancing the value of the acquired knowledge and skills [35].

New trends in education indicate that crowdsourcing technology has brought about a seismic shift in professional training and aspires to become an innovative paradigm for the development of higher education systems [36]. However, despite the wide range of applications of crowdsourcing in education, there is a noted inadequacy in harnessing the predictive capabilities of crowdsourcing in education, which are successfully utilized in other fields and hold value. There is very little literature on the organizational factors ensuring the successful implementation of crowdsourced forecasting [37]. Primarily, examples of forecasting future competencies based on foresight technology are provided, the accuracy of which largely depends on the professional competence not only of the participants but also of the facilitator of the foresight sessions [38]. In this regard, crowdsourcing technology is less costly and does not require personal presence, thereby facilitating the engagement of a larger number of participants. Furthermore, a significant challenge for researchers is the problem of measuring the results of crowdsourcing, characterized by a lack of conceptual consistency and integrity in approach, hindering comparisons, diverse methodological approaches, as well as the inaccuracy and inadequacy of the methods used for measurement [39].

In light of the aforementioned, to address these gaps, an experimental study was conducted on the use of crowdsourcing technology as a predictor of universal competencies among future professionals in the higher education system. The ability to conduct effective forecasting is one of the important tasks for universities. Since they are responsible for professional training and also study demand, determining the competencies that graduates should possess to tailor educational training programs accordingly is crucial at present.

3. RESEARCH METHOD

3.1. Research design

The study was conducted at the East Kazakhstan University, named after Sarsen Amanzholov, from September 2022 to December 2023. The empirical study on the use of crowdsourcing as a predictor of universal competencies among future professionals in the labor market was conducted in three stages (organizational, research, and analytical). The first stage – organizational, included all organizational aspects of the experiment, namely creating a technological platform for conducting crowdsourcing on the research topic, preparing informational content for the crowdsourcing platform, and attracting participants to crowdsourcing. To develop the technological platform, the programming languages JavaScript, WordPress, XAMPP, PHP, Perl, and MySQL were used. The interface of the crowdsourcing platform has a multi-module architecture: a site analytics block that automatically collects and aggregates data, an administration block, and a client program. The interface architecture is oriented towards different user groups and includes the following functional capabilities: registration process on the portal; search and navigation on the portal; news portal and documents on the portal; communication and feedback with users, including conducting voting. To facilitate users' work with the software, a video guide was provided, which strictly regulates the registration process, communication, and voting procedure.

The preparation of informational content for the crowdsourcing platform was carried out taking into account the key mechanisms (information gathering, dissemination, and interpretation differences) that enhance the accuracy of crowdsourcing initiatives forecasting. To collect and establish a minimum baseline level of general information for all participants, reference information was provided (lists of competencies developed for various fields of study in universities of the Republic of Kazakhstan, presentation of EP rankings in the Republic of Kazakhstan, video interviews with developers of EPs, experts, scientists on possible challenges, and threats). The technological capabilities of the developed crowdsourcing platform (taken into account during its development) allow participants to view aggregated differences in information about the forecasts of other participants in real-time mode. The transit of information from more knowledgeable participants to less informed ones enable them to acquire new and refined knowledge, enhancing their understanding, which in turn increases the accuracy of their forecasts.

Guided by the principle that the greater the difference in interpretations that participants use for their forecasts, the higher their accuracy will be, participants belonging to different social groups, geographic regions, with different functional responsibilities, varying levels of experience, tenure, education, knowledge, perspectives, skills, or abilities were attracted. The target audience was engaged through personalized invitations to potential employers, business representatives, and civil activists, as well as by posting announcements on the university's website and distributing information through social networks. Utilizing existing agreements on international cooperation, invitations were sent via email to institutions within the academic community. As a motivational incentive, the most active participants were offered monetary rewards and co-authorship in future universal EPs determined by general voting. The second stage, the research phase, was aimed at the direct implementation of crowdsourcing. Crowdsourcing forecasting was conducted separately for each direction of professional training, with a duration of 3-4 weeks per direction. Announcements about the crowdsourcing tour were posted on the news portal and automatically distributed to registered participants. The third stage, analytical in nature, entailed processing the obtained results and their interpretation.

The crowdsourcing process algorithm included the information collection, involving familiarizing participants with the rules of crowdsourcing, as well as with the lists of competencies being formed in EPs. The EPs themselves were presented in the form of video presentations. At this stage, participants were invited to assess the quality of the provided EPs. For this purpose, questionnaires were specially developed separately for each social group. The questions aimed to determine the level of correspondence of the competencies being formed among future specialists in the fields of agricultural and veterinary sciences, engineering and IT technologies, natural sciences and mathematics, and social sciences and humanities. The next part was the idea generation – during this stage, participants discussed and proposed their ideas and suggestions for the crowdsourcing task: "In your opinion, what universal competencies should a specialist in this field acquire to be in demand and competitive in the labor market in the future? Why?" and "the available comment function allowed all registered participants to express their opinions on various ideas, make adjustments, or propose new ideas based on their professional experience, perspectives, or needs, among other factors." The next part (idea filtering), based on the ranking of aggregated data, ideas, opinions, were filtered and structured according to their meaning and significance. The last part (voting), after structuring and refining, the key trends of the predicted universal competencies were presented on the platform for voting. Participants were required to rank the predicted universal competencies on a 5-point scale based on their level of demand.

3.2. Sample

In forecasting the universal competencies of future specialists, a total of 1,645 individuals participated. Among them were prospective students (564 individuals), potential employers (619 individuals), and practicing professionals with higher education (462 individuals). The distribution of participants by professional training areas and fields of activity was as: in the natural-mathematical direction (387 individuals); in the engineering and IT technology direction (454 individuals); in the agricultural and veterinary direction (369 individuals); in the social-humanitarian direction (435 individuals).

The criterion for selecting participants was the possession of higher education and the inclusion of students and prospective students who are already studying or planning to study in the considered areas of professional training. The number of participants allows us to speak about the validity and reliability of the sample for solving the set tasks. To increase the diversification of participants' activities, the registration process did not include demographic information (aimed at determining personal data, gender, and place of work). Only the direction of professional activity and affiliation with a social status were indicated, which was conventionally divided into three groups. The first group – university students and prospective students planning to enroll in the considered areas of professional training in higher education institutions. The second group – potential employers (business representatives, heads of state structures, and organizations). The third group – professionals with higher education, including university graduates and practitioners.

3.3. Data analysis

To generalize the results and process them, the following methods were applied. Quantitative-qualitative analysis used to process the results of online surveys to determine the quality of EPs in the fields of agricultural and veterinary education, engineering and IT technologies, social-humanitarian, and natural-mathematical cycles. Content analysis employed to structure the proposed ideas, opinions, and other content based on their meaning and significance. Ranking utilized to assess the level of demand for predicted universal competencies in the future job market, included five gradations: i) highly demanded (5 points); ii) demanded (4 points); iii) desirable (3 points); iv) less demanded (2 points); and v) not significantly demanded (1 point). Analysis of variance (ANOVA) applied to determine consensus among social groups in forecasting by testing the significance of differences between the mean values of the demand for future universal competencies in the labor market.

Crowdsourcing forecasting raises several ethical concerns: participants should receive fair compensation for their contributions, participants should be fully informed about how their ideas will be used, and they should have rights to intellectual property (in our case, co-authorship in EPs). In the study, the computer program SPSS statistics was utilized for processing the results. The limitations is the study does not encompass all spheres of professional activity, highlighting the need for further research in this area.

4. RESULTS

In accordance with the research algorithm, data from online surveys of 1,645 participants were processed to assess the quality of EPs in agricultural and veterinary education, engineering and information technology (IT) technologies, social-humanitarian, and natural-mathematical fields implemented in universities of the Republic of Kazakhstan. The results indicate that for the natural sciences and mathematics track, more than half (55% of 141 respondents from this social group) of prospective students rated the level of the EP as high, 30% as medium, and 15% as low. Among potential employers (a total of 153 participants), the majority rated the quality of the implemented EPs as medium (45%). A similar assessment of EP quality was made by most practitioners (52% of 93 participants), who also evaluated it as a medium.

For the engineering and IT technology track, a similar pattern was observed: the majority of prospective students (45% of 159 respondents) rated the quality of the EP as high, while among potential employers (56% of 163 respondents) and graduate practitioners (44% of 132 respondents), the medium level of EP quality prevailed. A somewhat different level of satisfaction with the quality of the EP is observed for the agricultural and veterinary training track: most prospective students (50% of 122 participants) rated the quality of the EP as medium, and similarly, among potential employers (48% of 148 respondents), the medium level of EP quality predominated. However, among practitioners (44% of 99 participants), the high-quality level of the EP was the most common.

In the social sciences and humanities track, it was found that a significant majority of prospective students (75% of 142 respondents) rated the quality of the EP as high, with no prospective students rating it as low quality. Potential employers (48% of 155 respondents) and practitioners (43% of 138 respondents) generally considered the quality of the presented EP as medium. The results of the online survey on assessing the quality of implemented EPs in various professional training areas are presented in Table 1.

Content analysis of crowdsourcing forecasts with the subsequent systematization of the obtained information has allowed the formulation of a pool of key trends in future universal competencies across professional training domains. The forecasted future universal competencies are directed toward subjective, social, and professional development. For the natural sciences and mathematics cycle, seven main universal competencies have been identified, while for the engineering and IT technology direction, participants' ideas and opinions have been summarized into six competencies. For the professional training domains of agricultural, veterinary, and social-humanitarian education, seven competencies have been defined. The highlighted key trends in training directions, forecasted by crowdsourcing participants, are presented in Figure 1.

In general, the results of the ranking of future universal competencies by demand indicate that the most anticipated competencies are project management competencies (x=8.4), 3D modeling and computer graphics (x=8.1), logistics outsourcing (x=8.1), and digital competencies (x=8). By fields of professional training, the results are as: for the natural sciences and mathematics track, project management competencies (x=8.4) stand out; for engineering and IT technologies, competencies in neural networks and big data (x=7.9) are most prominent; for agricultural and veterinary training, logistics outsourcing (x=8.1) is highlighted; and for the social sciences and humanities track, virtual reality (VR) competencies (x=7.4) and analytics (x=7.4) are most in demand.

Table 1. Results of questionnaires to determine the level of quality of EPs at universities

Fields	Participants (total 1,645 individuals)	Number of participants by fields	High level		Medium level		Low level	
			Number of individuals	%	Number of individuals	%	Number of individuals	%
Natural sciences and mathematics cycle (total of 387 participants)	Prospective students	141	78	55	42	30	21	15
	Potential employers	153	31	20	69	45	53	35
	Practicing specialists	93	22	23	48	52	23	25
Engineering and IT technologies (total of 454 participants)	Prospective students	159	72	45	59	37	28	18
	Potential employers	163	19	12	91	56	53	32
	Practicing specialists	132	40	30	58	44	34	26
Agricultural and veterinary education (total of 369 participants)	Prospective students	122	52	43	61	50	9	7
	Potential employers	148	34	23	71	48	43	29
	Practicing specialists	99	43	44	32	32	24	24
Social and humanitarian direction (total of 435 participants)	Prospective students	142	106	75	36	25	-	-
	Potential employers	155	34	22	74	48	47	30
	Practicing specialists	138	41	30	60	43	37	27

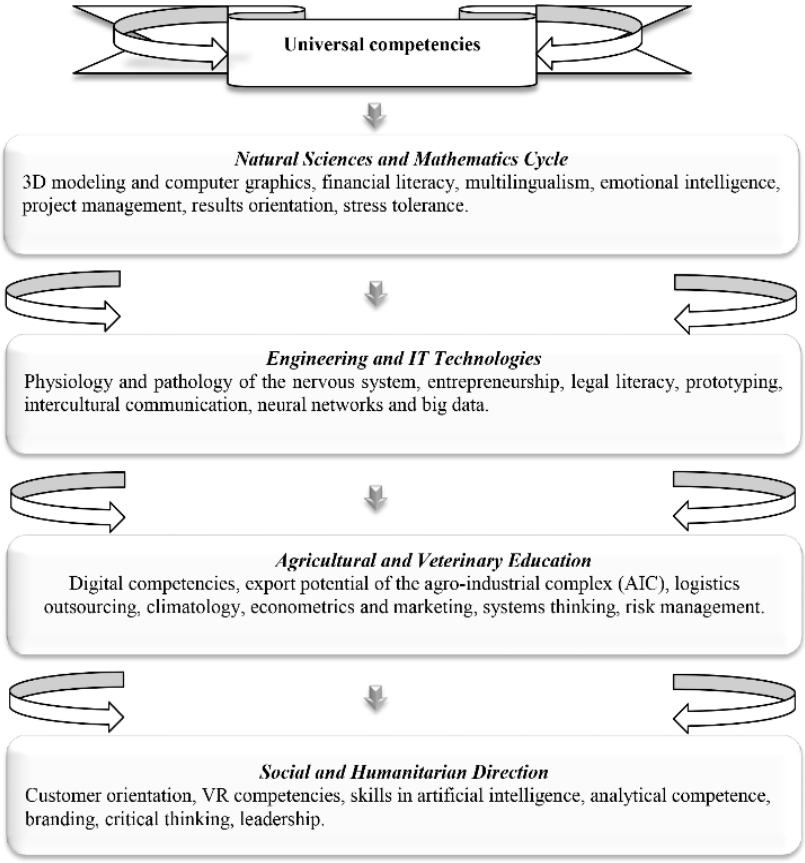

Figure 1. Key trends of future universal competencies by professional training areas

The analysis of the ranking results among social groups revealed that the majority of prospective students, in their forecasts for the natural sciences and mathematics domain, focus on the demand for universal competencies such as “resilience” (x=2.8) and “project management skills” (x=2.7). They argue that attributes such as the ability to remain calm in stressful situations and to react constructively to conflict are particularly sought after in their future professional endeavors. Among potential employers, different opinions prevail. They emphasize that professionals in the natural science and technology sectors play a crucial role in project activities, the quality of which will directly influence the development of industries as a whole and the efficiency of scientific research. Therefore, the most sought-after competencies will be “project management skills” (x=2.9) and “results orientation” (x=2.8). Practitioners believe that competencies in 3D modeling and computer graphics (x=2.8) will be necessary for studying biological, geographical, and ecological processes, as well as for visualizing problems in solving professional tasks.

In the field of engineering and IT technologies, a significant portion of prospective students predict competencies in areas such as “entrepreneurship” (x=2.7) and “legal literacy” (x=2.6). Potential employers

consider competencies in “prototyping” (x=2.9) and “neural networks and big data” (x=2.8) to be the most sought-after. Practitioners predominantly forecast competencies in the field of artificial intelligence (AI): “neural networks and big data” (x=2.8) and “physiology and pathology of the nervous system” (x=2.7), considering these areas particularly promising.

In the field of agricultural and veterinary education, among the group of “prospective students”, the highest average values are observed for digital competencies (x=2.9) and “systems thinking” (x=2.7). Among potential employers, high average values are obtained for “risk management” in agriculture (x=3.0) and “export potential of the agro-industrial complex” (x=2.8). In the group of practitioner specialists, there are predominating average values for competencies such as “logistics outsourcing” (x=2.8) and “econometrics and marketing” (x=2.7).

Regarding the socio-humanitarian direction, the situation is as: among prospective students, average values for “leadership” (x=2.9) and “analytics” (x=2.7) predominate; among potential employers, “customer orientation” (x=2.9) and “branding” (x=2.6) are prominent; among practitioner specialists, “VR competencies” (x=2.8) and “customer orientation” (x=2.7) are notable. The results of ranking by the degree of demand for future universal competencies in the directions of professional training are presented in Table 2.

To verify the results of the ranking, a one-way ANOVA was conducted based on the variable of the perceived demand for future universal competencies across different social groups. The results are presented in Table 3. The use of this statistical method is justified by the underlying assumptions: normal distribution of the studied variable across the compared groups (i.e., the projected level of universal competencies among future specialists), homogeneity of variances, and the randomness and independence of the samples. Specifically, the assumption of normality was tested using the Shapiro–Wilk test, which, at a significance level of α=0.05, yielded a p-value of 0.6303 and a test statistic W of 0.9896. This result falls within the 95% acceptance region: [0.861, 1], indicating that the data follow a normal distribution. The assumption of homogeneity of variances was assessed using Levene’s test. The test yielded an F-statistic of 0.869895, which lies within the 95% acceptance interval: [0: 3.1138], and the p-value exceeded the significance threshold (p=0.42302>0.05). Therefore, the differences between the sample variances of the groups were not statistically significant, confirming the homogeneity of variances. The data are presented in Table 4.

Table 2. Results of ranking by the degree of demand for future universal competencies by professional training areas

No	Universal competencies	Overall average (X cp)	Prospective students (X cp)	Potential employers (X cp)	Practicing specialists (X cp)
Natural science and mathematics cycle					
1	3D modeling and computer graphics	8.1	2.6	2.7	2.8
2	Financial literacy	4.6	1.3	1.5	1.8
3	Multilingualism	5.9	1.6	2.1	2.2
4	Emotional intelligence	7.2	2.5	2.4	2.3
5	Result orientation	6.7	1.2	2.8	2.7
6	Stress resilience	5.7	2.8	1.4	1.5
7	Project competencies	8.4	2.7	2.9	2.8
Engineering and IT technologies direction					
1	Physiology and pathology of the nervous system	6.9	2.4	1.8	2.7
2	Entrepreneurship	6.4	2.7	1.4	2.3
3	Legal literacy	7.8	2.6	2.7	2.5
4	Prototyping	7.6	2.1	2.9	2.6
5	Neural networks and big data	7.9	2.3	2.8	2.8
6	Intercultural communication	7.2	2.4	2.3	2.5
Agricultural and veterinary education direction					
1	Digital competencies	8	2.9	2.5	2.6
2	Export potential of the agro-industrial complex	7.8	2.5	2.8	2.5
3	Logistics outsourcing	8.1	2.6	2.7	2.8
4	Climatology	5.8	1.8	1.7	2.3
5	Econometrics and marketing	6.9	2.0	2.2	2.7
6	Systems thinking	7.8	2.7	2.6	2.5
7	Risk management	7.6	2.4	3.0	2.2
Social and humanitarian direction					
1	Customer orientation	6.9	1.3	2.9	2.7
2	VR competencies	7.4	2.3	2.3	2.8
3	AI proficiency	6.8	2.2	2.5	2.1
4	Analytics	7.4	2.7	2.4	2.3
5	Branding	6.1	1.6	2.6	1.9
6	Critical thinking	5.1	1.2	2.2	1.7
7	Leadership	5.9	2.9	1.4	1.6

Note: the table shows the average values (X).

Since the mean values for certain projections of future universal competencies differ across groups, post hoc comparisons were conducted using the Tukey–Kramer criterion. The results confirmed that there were no statistically significant differences in variances between any pair of groups. The data are presented in Table 5. The results of the conducted analysis indicate that the ranking results are confirmed. No significant differences were found in the indicators of competencies such as 3D modeling and computer graphics, multilingualism, emotional intelligence, project management competencies, legal literacy, neural networks and big data, intercultural communication, digital competencies, export potential of the agro-industrial complex, logistics outsourcing, systems thinking, VR competencies, skills in AI, analytics, and critical thinking. This suggests that a consensus has been reached among the social groups regarding these universal competencies in the forecasts. Statistically significant differences in the forecasts of universal competencies were found for the following indicators: financial literacy, results orientation, stress resistance, physiology and pathology of the nervous system, entrepreneurship, prototyping, climatology, econometrics and marketing, risk management, client orientation, branding, and leadership.

Table 3. ANOVA analysis of mean values based on the demand for universal competencies among future professionals

Source	Descriptive statistics			ANOVA	
	Sum of squares	Degrees of freedom	Mean square	F-statistic	P-value
3D modeling and computer graphics	35.93	11	4.581	2.172	0.15
Financial literacy	11.079	3	2.693	8.19*	0.02
Multilingualism	18.53	7	1.831	3.28	0.07
Emotional intelligence	29.3	5	1.727	2.09	0.80
Results orientation	23.29	5	0.176	7.11*	0.01
Stress resilience	16.25	7	2.154	13.84*	0.02
Project competencies	39.199	5	2.652	3.12	0.94
Physiology and pathology of the nervous system	24.93	10	3. 267	6.123*	0. 04
Entrepreneurship	22.099	7	1.156	5.121*	0. 01
Legal literacy	34.34	5	3.164	0.165	0.42
Prototyping	31.76	4	1.245	12.45*	0.01
Neural networks and big data	33.849	8	3.238	2.09	0.34
Intercultural communication	28.340	10	6.233	1.134	0.94
Digital competencies	35.92	7	4.176	1.188	0.722
Export potential of the agricultural sector	34.34	5	5.457	2.134	0.872
Logistics outsourcing	35.93	10	2.561	1.589	0.431
Climatology	17.54	5	1.562	7.11*	0.01
Econometrics and marketing	24.93	2	6.123	9.23*	0.00
Systems thinking	34.34	5	3.764	2.452	0.767
Risk management	34.00	11	3.569	8.65*	0.02
Customer orientation	24.93	5	3.123	15.33*	0.01
VR competencies	28.999	7	5.233	2.78	0.78
Ai skills	26.500	10	3.149	1.378	0.45
Analytics	31.299	7	4.189	2.673	0.52
Branding	21.25	5	3.786	7.11*	0.01
Critical thinking	14.45	7	3.726	3.156	0.54
Leadership	21.049	8	2.178	11.43*	0.01

Note*: statistically significant at the 0.05 level

Table 4. Results of variance homogeneity testing (Levene's test)

Source	Degrees of freedom	Sum of squares	Mean square	F statistics	P-value
Groups (between groups)	2	0.1914	0.09568	0.8699	0.423
Error (within groups)	78	8.5793	0.11		
General	80	8.7706	0.1096		

Table 5. Results of post hoc comparison (Tukey–Kramer test)

Pair	Difference	Standard error of the difference	Test statistic	Lower confidence interval of the difference	Upper confidence interval of the difference	Critical mean	p-value
x1-x2	0.01852	0.06383	0.2901	-0.1971	0.2342	0.2157	0.9771
x1-x3	0.1111	0.06383	1.7409	-0.1046	0.3268	0.2157	0.4387
x2-x3	0.09259	0.06383	1.4507	-0.1231	0.3083	0.2157	0.5629

5. DISCUSSION

According to the center for labor resource development of the Republic of Kazakhstan, various forms of unemployment are observed in the country, one of the reasons being the mismatch between professional training and labor market requirements, thereby leaving job seekers unable to find employment.

Employers prefer to see future specialists possessing a specific set of competencies, while prospective students, based on their perceptions, emphasize the development of other competencies, which are deemed less significant by employers. Conversely, practitioner specialists have their perspectives based on their professional experience.

In this context, the study of successful global practices in the use of crowdsourcing for addressing specific challenges made it possible to implement the technology of the crowdsourcing process into the university's educational framework for forecasting universal competencies that are expected to be in demand in the future labor market. The unique feature of utilizing crowdsourcing as a predictive tool lies in enabling interaction among all participants at each stage while taking into account the core mechanisms of crowdsourcing, namely information collection, information dissemination, and diversity of interpretation. Each stage of the process serves a distinct purpose and involves the specific implementation of these mechanisms. By following these stages, any educational institution can independently implement a crowdsourcing project using its own resources.

At the initial stage of crowdsourcing-based forecasting (information collection), the objective was to establish a minimum baseline level of general understanding among participants regarding the subject matter. To achieve this, participants were provided with lists of competencies developed within the university's EPs, along with video presentations of the programs. Given that monitoring participants' capabilities is a fundamental challenge in crowdsourcing—essential for drawing conclusions about their future performance in assigned tasks and identifying opportunities for improvement—it was proposed to assess the degree of alignment between the quality of the university's EPs and the requirements of the labor market.

The results of the online survey to determine the quality of implemented EPs not only indicate a gap between the vision of scientific and pedagogical personnel regarding the professional training of future specialists and the current needs of society but also between the consumers of educational services. While most prospective students believe that the presented EPs take into account modern trends in education and adequately reflect the areas of professional activity after graduation, potential employers and practitioner specialists, on the contrary, feel that the competencies developed in EPs do not fully correspond to the qualifications, thus inadequately ensuring the competitiveness and demand of future graduates. The opposed assessment of the quality of EPs by participants in the "prospective students" group may be due to two factors described in studies on transforming the image of a profession on the path to future employment of university graduates. The essence of these factors lies in the fact that many prospective students, upon entering university, are not guided by clear perceptions of their chosen profession but by its subjective image. On the other hand, it may be the case that during internships, students do not acquire sufficient professional skills, leading to an incomplete picture of the necessary competencies for their future profession.

The opportunity provided on the crowdsourcing platform to view aggregated differences in other participants' forecasts in real-time during the idea-generation stage facilitated the dissemination of information from more knowledgeable participants to those less informed. This enabled prospective students to acquire new and refined knowledge, improve their understanding, and enhance the accuracy of their own forecasts. In turn, processing newly acquired information through diverse interpretations—from the perspective of students or individuals at other professional or hierarchical levels—contributed to improving the accuracy of all participants' forecasts by broadening the scope of assumptions. Thus, incorporating the core mechanisms of crowdsourcing in the organization of forecasting activities not only increases the accuracy of predictions but also contributes to the professional development of individuals across different levels of social stratification.

Considering the absence of a unanimous viewpoint on the organization, measurement of results, and selection of measurement tools for crowdsourcing outcomes, the design, and methodology of crowdsourcing forecasting in the research were modified to align with the research objectives, taking into account the key mechanisms (information gathering, dissemination, and interpretation differences) that enhance forecast accuracy [40]. To achieve this, participants from different professional strata were engaged, and reference information was provided on the platform for data collection. The functionality of the developed crowdsourcing platform allowed participants to view forecasts from other participants in real-time. According to Campos-Blázquez *et al.* [40], the measurement of crowdsourcing and tools for measuring crowdsourcing results should encompass consensus decision-making and reflect both quantitative and qualitative aspects of the obtained results. A quantitative-qualitative approach in crowdsourcing forecasting of future universal competencies is represented by methods such as content analysis, ranking, and comparative analysis of mean values using the variance analysis ANOVA. The selection of these methods as measurement tools is justified by the fact that content analysis enables the consolidation of poorly structured opinions, ideas, and suggestions of participants into a unified denominator based on frequency and meaning. Ranking aids in determining the level of demand for future universal competencies from various positions within the hierarchical structure of professional stratification. The variance analysis ANOVA criterion is employed to determine consensus decision-making in the absence of significant differences.

Based on a qualitative analysis of crowdsourcing results, a pool of future key trends in universal competencies was formulated, aligning with widely acknowledged forecasts of future hard, soft, and digital skills. However, unlike previous studies where it is believed that in the future, the most in-demand competencies will be those related to subjective development, participants in the crowdsourcing forecasts predominantly emphasized subject-specific competencies. Out of 27 predicted universal competencies, 17 competencies consist of hard and digital skills (in areas such as computer graphics, 3D modeling, AI, prototyping, logistical outsourcing, econometrics and marketing, export potential of the agricultural sector, branding, management, and climatology, among others). The prevalence of subject-specific competencies in forecasting, which can be seen as new professional challenges, might be a consequence of the increasing volatility in the Kazakhstani labor market. It is known that volatility requires companies to combine and utilize diverse sets of subject-specific competencies among specialists, including those from other professional fields worldwide, which complement each other and enable them to effectively perform their professional tasks. Furthermore, the most significant problem for developing countries is the shortage of skilled technical and qualified professionals [41]. The presence of relevant competencies among workers is crucial in addressing labor market volatility. Consequently, considering the development and changes across all sectors/fields of the country and the state of the labor market in terms of professions is an important component in the methodology of crowdsourcing forecasting of future competencies.

The quantitative measurement of the demand for future universal competencies among social groups confirms the findings of numerous studies [42]–[44], indicating that forecasting among representatives of different hierarchical structures faces obstacles in the form of behavioral preferences. These preferences entail that an individual's choice and decision-making (in our case, ranking by the degree of demand for future universal competencies) will depend on their perceptions of their abilities and possibilities, favoring activities in which they are more engaged. For this reason, crowdsourcing participants tended to prefer competencies in which they were more interested, which adequately demonstrates the significant disparities in ranking results among participants from different social groups. Forecast accuracy is further enhanced through the incorporation of diverse perspectives on forecasting from various professional and social hierarchical levels [45]. Additionally, studies have shown that engaging individuals with different skills and knowledge provides a positive opportunity for knowledge exchange (for example, combining more competent and less experienced employees in one team) [46]. In crowdsourcing, ensuring consistency across hierarchies is achieved through consensus decision-making; otherwise, decision-making participants will plan using different views of the future, leading to conflicting decisions within their sectors. We consider this assertion to be evidence supporting the concept of crowdsourcing as a valuable innovation in the educational segment based on collective participation.

The hypothesis testing aimed at verifying whether the results of crowdsourced forecasting, when validated through comparative analysis across social groups, would enable the identification of consensus-based decision-making was conducted using Levene's test and one-way ANOVA. The results indicated homogeneity of variances and the absence of statistically significant differences among the three social groups. Therefore, it can be concluded that a consensus was achieved in the forecasts of universal competencies across the social groups: 3D modeling and computer graphics, multilingualism, emotional intelligence, project management competencies, legal literacy, neural networks and big data, intercultural communication, digital competencies, export potential of the agro-industrial complex, logistics outsourcing, systems thinking, VR competencies, AI proficiency, analytics, and critical thinking. This is confirmed by the results of the ANOVA analysis, which show no significant differences in the mean values.

6. CONCLUSION

The research has expanded the spectrum of using the predictive capabilities of crowdsourcing, particularly within the system of higher professional education. The monitoring of participants' capabilities during the information-gathering stage of the crowdsourcing process revealed a significant gap between the perceptions of professional training held by future specialists and those of potential employers and industry practitioners. Incorporating the core crowdsourcing mechanisms into the forecasting process organization enabled participants to acquire new and refined knowledge, achieve a deeper understanding of the subject matter, and improve the accuracy of their forecasts. Through a quantitative-qualitative approach, the existing gap in measuring and selecting measurement tools for crowdsourced forecasts has been addressed. It has been established that in the forecasts of crowdsourcing participants, subject-specific competencies prevail over competencies related to subjective and social development, the demand for which in the study is explained by the increasing volatility of the Kazakhstani labor market. It has been confirmed that in forecasting the degree of demand for future universal competencies, participants from different professional strata tend to prefer competencies in which they are most interested. However, the research hypothesis was confirmed by the results of Levene's test and one-way ANOVA. In this regard, the conclusion about the

value and usefulness of using crowdsourcing as a predictor in the educational segment is justified, allowing for the forecasting of the demand for future universal competencies from various professional positions, thus contributing to the improvement of forecast accuracy.

Thus, the use of crowdsourcing for forecasting in the educational segment has not only allowed for the identification of future key trends in universal competencies but also for the specification of their demand across professional sectors, the identification of existing gaps in EPs, and the strengthening of feedback between universities and educational service consumers. The formulated profile of future universal competencies across professional training directions is important and useful as an additional guideline for EP developers, while the provided design and detailed methodology of crowdsourcing forecasting can be utilized or adapted for prompt solutions to other pertinent issues facing the higher education system. Taking into account various factors (participants' level of professional competence, individual characteristics) influencing forecast accuracy underscores the feasibility of further research into crowdsourcing forecasting in the educational segment. Research evaluating the accuracy of crowdsourced forecasts compared to actual outcomes in education appears to be particularly promising in this field.

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AUTHOR CONTRIBUTIONS STATEMENT

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C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
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O : Writing - **O**riginal Draft
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Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

This research has no conflict of interest.

INFORMED CONSENT

We have obtained informed consent from all individuals included in this study.

ETHICAL APPROVAL

The research related to human use has been complied with all the relevant national regulations and institutional policies in accordance with the tenets of the Helsinki Declaration and has been approved by the authors' institutional review board (Sarsen Amanzholov East Kazakhstan University Ethics Committee, Protocol No 3561 of July 12, 2022).

DATA AVAILABILITY

The authors confirm that the data supporting the findings of this study are available within the article [and/or its supplementary materials].

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