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SHAPING FUTURE SCIENTISTS: THE ROLE OF IZHO IN INFLUENCING STEM INTERESTS AND SKILL DEVELOPMENT AMONG HIGH SCHOOL STUDENTS

Abstract. This study examines the impact of participation in the International Zhautykov Olympiad (IZhO) on high school students' perceptions of 21st-century skill development and STEM career aspirations. Using a mixed-methods approach, the research investigates gender differences, variations across STEM specializations, age-related trends, school-type influences, and the effect of repeated participation. The findings revealed significant gender differences, with female students reporting greater improvements in Presentation, Scientific Thinking, and Collaboration skills compared to males. No significant differences were observed across STEM specializations, suggesting that IZhO contributes similarly to skill development across Mathematics, Physics, and Informatics students. Age analysis indicated that younger students (13–14 years old) perceived greater skill enhancement than older groups, particularly in General Skills, Presentation, and Problem Solving. Vocational school students reported the highest perceived benefits in Technology skills compared to public and private school counterparts. Additionally, a moderate frequency of Olympiad participation (10–20 times) was associated with the greatest improvement in Critical Thinking skills. These findings highlight the potential of Olympiad participation to foster essential skills and inspire STEM career aspirations. They also suggest the need for tailored interventions to address age- and gender-specific needs, maximize benefits for all school types, and explore strategies to sustain students' engagement over repeated participation. The study underscores the value of STEM competitions in preparing students for future academic and career success.

Keywords: STEM education, 21st-century skills, Olympiad participation, skill development, gender differences, STEM careers.

Introduction

The International Zhautykov Olympiad (IZhO) serves as a prestigious platform for high school students to engage in advanced problem-solving and showcase their abilities in STEM (Science, Technology, Engineering, and Mathematics) subjects such as Physics, Mathematics and Computer Science. Despite the increasing recognition of Olympiad competitions as catalysts for skill enhancement and career inspiration, limited research explores their specific impacts on students' perceptions of skill development and aspirations for STEM careers.

This study seeks to address this gap through investigating how IZhO participation influences students as they view skill improvement and aspire to careers. It explores if these ideas are formed through items like sex, years, topic focus, school form, and involvement rate. Educators as well as policymakers must have a comprehension of these dynamics. If they design programs that are inclusive and also effective, they can maximize all the benefits of such competitions for diverse student populations.

Several of the key questions that guide this research are these: Do gender differences actually exist within perceived skill development which results directly from IZhO participation? Do students of all of the different STEM disciplines perceive some benefits? Specialization may change these benefits. How do people perceive skill improvements? How do career aspirations depend on age? What school type reports about participation's greatest benefits? How does the participation frequency impact STEM career interests and students’ skill development perceptions?

Sahin et al. (2015) survey is used in the study to explore these questions because it assesses factors influencing students' career choices and skill development through Olympiad participation. This research, through analyzing IZhO participant responses, gives perceptions regarding how competitions do help inspire future STEM experts as well as foster vital skills. For skill-building opportunities, they should be equitably accessible for those within competitive academic environments since the findings offer valuable STEM education strategy optimizations.

Literature Review

Science Olympiad Benefits

Students can participate in the Science Olympiad to showcase their skills, in STEM fields at competition levels – events and even on the global stage like the IZhO. Some of the competitions within this realm are the International Physics Olympiad and International Chemistry Olympiad. Taking part in these contests offers benefits, like chances of getting into top universities (Lim et al., 2014) shaping career aspirations positively for long term success in STEM fields (Smith et al., 2021). Additionally, engaging in these competitions helps develop skills for the age such as communication, teamwork and adaptability.

The IZhO is designed for high school students. Includes tests in physics, mathematics and informatics to spark curiosity and enhance problem solving abilities well as critical thinking skills among participants. Students are evaluated through both theory and experiments. Studies related to the similar Olympiads such as International Junior Science Olympiads (IJSO), often focus on examining the interest profiles of participants (Dierks et al., 2014; Höffler et al., 2019). Research conducted as subsequent studies (Höffler et al., 2017), have explored topics such as social self-perception and social emotional wellness with findings also reported (Nadhirah et al., 2019). Dierks et al. (2014) for example used the RIASEC framework to analyze the interests of students, in science competitions. They found traits that set apart those involved in science contests. In a study Höffler et al. (2017) it was discovered that participants in science competitions displayed self-perceptions compared to those who did not participate and sports competitors. However, girl participants exhibited self-perceptions despite having academic achievements.

In their study Nadhirah et al. (2019) explored the social skills of students participating in science olympiad during quarantine. They found that these students faced difficulties in managing their emotions, resolving conflicts and interacting socially despite their abilities. This highlights the influence of the science olympiad on students' academic growth.

Factors Influencing Students' STEM Career Interests

Scientific Olympiads effectively spark interest in STEM careers so that science develops sustainability in such a major role (Baskaran, 2016). If students participate within these competitions, they gain hands-on experience and analyze skills. Role models in STEM as well as supportive educational settings can shape long-term career interests greatly. Individual and also social and environmental factors do all influence STEM career paths. These factors affect students in particularity. From an age, personal characteristics such as inquisitiveness and self-assurance play a role in interest in STEM subjects (Campbell et al., 2017). Finnish athletes are keen on sports since mathematics and literature were introduced and German participants are driven to mention it as key and Chinese Olympians find family support important, stressing that. These results were confirmed by Smith et al. (2021), who highlighted how self-assurance and curiosity affect Olympians' career decisions in a study. Sahin et al. (2015) reported gender disparities in STEM field preferences. Top et al. (2015) supports this finding as well. Men prefer engineering while women are more attracted to environmental studies. Engagement in Science Olympiad competitions, another study conducted by Top et al. (2015) uncovered, offers recognition also acts as a strong incentive toward securing scholarships. When students perform well, higher grades may influence in a positive way their interest within STEM for the reason that they are attracted toward science and technology subjects (Balta et. al., 2023a; Japashov et. al., 2022).

Interest within STEM fields may also be impacted through family relationships such as parents' jobs and siblings' number. Japashov et. al. (2022) showed interest levels differ based on family size

and Balta et. al. (2023a) study even found a link of siblings as well as career interests. That interest was specifically for math related careers. Support for family is also another important factor. Role models do matter in this context too! For career goal navigation, it can be influenced through family size and also its impact on achievements (Black et al., 2005; Japashov et. al. 2022).

Improving these aspects related to society and the environment. Such as differences, between genders in STEM fields and how teamwork and family connections play a role. Can boost students' pathways towards careers, in science and technology fields while also fostering progress and creativity.

Factors in the environment that influence interest in STEM fields include support from authorities and job prospects as educational regulations in place for students wanting to pursue STEM education and careers. Lim et al. (2014) conducted attention to Singapore's efforts in promoting interest in STEM subjects through initiatives like supporting competitions and offering development opportunities for educators. Research by Langdon et al. (2011) highlighted the earning potential of the earning potential of STEM professionals compared to those outside the field which contributes to the attractiveness of STEM occupations. Johnson (2012) revealed that despite a start and eagerness among stakeholders to implement STEM policies; challenges arise due to communication barriers hindering progress.

21st century skills development

The increasing focus on 21st century skills shows education adapting to fulfill needs (Agaoglu & Demir, 2020; Care et al., 2018; Chalkiadaki, 2018; Geisinger, 2016). Even though these skills are in fact not entirely just concepts, Sahin et al. (2015) highlight that they are now seen as important for thriving in today's technology dominated working environment. Research studies from varied perspectives have explored the cultivation of these skills. Research findings discuss project-based learning (PBL) (Baran et al., 2018). The emphasis here is on just how. Olympiad contests engaged Sahin et al. (2015) plus the study (Stehle & Peters-Burton, 2019) showed benefits.

In their work about 21st century skills, Beers (2011) describes these as abilities for professional growth that include critical thinking, creative problem solving, effective communication, cultural sensitivity, media literacy, revolutionary thinking, as well as skill in information and communication technology (ICT). Project Based Learning (PBL) is effective at fostering these competencies via encouraging students' independence, collaboration among peers, awareness of the environment and expertise in information technology as revealed by Baran et al. (2018). They made recommendations in order to further develop these skills. The training programs of educators should incorporate PBL. Stehle and Peters-Burton (2019) do also support the idea that these abilities should be integrated into teacher training programs by way of the STEM curriculum.

Moreover, STEM improves the quality of education by fostering critical thinking and problem-solving skills among students (Maxutov et al., 2023). Furthermore, Sahin et al. (2015) highlighted the impacts of engaging in Science Olympiad competitions, focusing on abilities, like communication, with others. Working together in teams while also emphasizing the importance of analytical thinking.

In terms and based on what has been written by experts, in the field of education and learning researches stress the importance of integrating skills training within educational systems. They highlight the benefits of using inquiry based teaching methods and encouraging students to participate in activities as crucial steps towards equipping them for achievement, in a world that heavily relies on technology and is constantly evolving.

Methodology

Research design

Researchers used a combination of methods to study how students benefit from taking part in IZhO and to understand what influences their interest in STEM careers and how their attitudes and 21st century skills develop over time. The use of this approach allows researchers to delve into topics by combining qualitative methods to improve the credibility and richness of their discoveries. As highlighted by Creswell and Clark (2017) the mixed method approach combines qualitative methods

for gathering and analyzing information. As Creswell (1994) qualitative research delves into social issues offering a comprehensive view, in real contexts while quantitative research focuses on numerical analysis and statistical procedures (Creswell, 2017).

In this research project's framework included an explanatory design, within which a mixed method approach was applied for investigation purposes. Quantitative data collection was used initially to uncover trends and connections among variables. Afterward qualitative data collection through interviews, as a research tool was utilized to offer insights and broaden the perspectives (Almeida, 2018; Creswell & Clark, 2017) showcase an approach to investigating research queries and amplifying the depth of the study's results.

Research questions

Are there differences in the perception of skill development among male and female students who participate in the IZhO?

Do high school students specializing in different STEM subjects (Mathematics, Physics, Informatics) perceive varying levels of improvement in 21st-century skills due to their participation in the IZhO?

What is the relationship between students' ages and their perceptions of how IZhO participation influences their development of 21st-century skills and aspirations for STEM careers?

Which type of school reports the highest perceived benefit from participating in the IZhO Olympiad regarding skill development and STEM career aspirations?

What is the relationship between the number of Olympiad participations and students' development of skills, and their aspirations for STEM careers?

Instrument

We used Sahin et al.'s (2015) survey in our research to explore how high school students view the factors affecting their career choices and their opinions on how participating in the International Science Olympiad influences their interests and skills, for the future. The questionnaire comprises a mix of choice and open-ended queries aimed at gathering data, on the profiles of Olympiad contestants as well as their past engagements with Science Olympiad events and the factors shaping their future intentions and views on how participating in Science Olympiad competitions impacts their career choices and academic progress, in contemporary skills.

Data analysis and results

Analysis of the quantitative data

The data collected through an online survey was analyzed using descriptive statistics, t-tests, one-way ANOVA, and two-way ANOVA via the Jamovi platform.

Descriptive Statistics

The skewness and kurtosis values for all the analyzed skills were calculated to assess the normality of the data distribution. Table 1 presents the descriptive statistics for the variables under study, including measures of central tendency, dispersion, and distribution characteristics.

Table 1. Descriptives

	Skewness	Std. error skewness	Kurtosis	Std. error kurtosis
General skills	-0.247	0.238	-0.280	0.472
Presentation	-0.210	0.238	-0.789	0.472
Scientific Thinking	-0.210	0.238	-0.789	0.472
Collaboration	-0.0052	0.238	-1.01	0.472
Problem Solving	-0.560	0.238	-0.604	0.472
Innovation	0.305	0.238	-0.822	0.472
Creativity	-0.0467	0.238	-1.09	0.472
Technology	0.327	0.238	-1.14	0.472
Critical Thinking	-0.450	0.238	-0.844	0.472
Life and Career	-0.122	0.238	-1.14	0.472

Gender difference

To examine gender differences in perceptions of skill development resulting from participation in the International Zhautykov Olympiad (IZhO), an independent sample t-test was conducted. The results indicated significant differences between male and female students for three specific skills: Presentation (p=0.005), Scientific Thinking (p=0.005), and Collaboration (p=0.021). These findings suggest that gender plays a role in shaping perceptions of IZhO's impact on these skills.

Table 2. Independent Samples T-Test

		Statistic	df	p
General skills	Student's t	-1.88	101	0.062
Presentation	Student's t	-2.88[1]	101	0.005
Scientific Thinking	Student's t	-2.88[1]	101	0.005
Collaboration	Student's t	-2.35[1]	101	0.021
Problem Solving	Student's t	-1.70[1]	101	0.092
Innovation	Student's t	-1.69	101	0.095
Creativity	Student's t	-1.22[1]	101	0.226
Technology	Student's t	-1.27[1]	101	0.208
Critical Thinking	Student's t	-1.49[1]	101	0.139
Life and Career	Student's t	-1.31	101	0.195

Further analysis of the mean values revealed that female students rated the contribution of IZhO to their skill development significantly higher than male students for Presentation, Scientific Thinking, and Collaboration skills. The differences in mean scores are presented in Table 3, illustrating that female students consistently reported greater perceived improvement in these skills.

Table 3. Group Descriptives

	Group	N	Mean	Median	SD	SE
Presentation	M	87	2.93	3.00	1.199	0.129
	F	16	3.81	4.00	0.544	0.136
Scientific Thinking	M	87	2.93	3.00	1.199	0.129
	F	16	3.81	4.00	0.544	0.136
Collaboration	M	87	2.75	3.00	1.340	0.144
	F	16	3.56	3.50	0.814	0.203

Subject Differences in Perceived Skill Improvement

To address the research question, "Do high school students specializing in different STEM subjects (Mathematics, Physics, Informatics) perceive varying levels of improvement in 21st-century skills due to their participation in the IZhO Olympiad?", a one-way ANOVA (Welch's) (see Table 4) was conducted to examine differences in skill improvement perceptions across the three subjects.

The analysis revealed that there were no statistically significant differences in perceived skill improvement among students specializing in Mathematics, Physics, or Informatics for any of the 21st-century skills assessed. The p-values for all skills exceeded the threshold of significance ($p > 0.05$). This suggests that students from different STEM subject specializations perceive their participation in the IZhO Olympiad as contributing similarly to their development of 21st-century skills.

Table 4. One-Way ANOVA (Welch's)

	F	df1	df2	p
General skills	0.2411	2	63.1	0.787
Presentation	1.8370	2	62.9	0.168

[1] Levene's test is significant ($p < .05$), suggesting a violation of the assumption of equal variances

	F	df1	df2	p
Scientific Thinking	1.8370	2	62.9	0.168
Collaboration	1.4480	2	62.6	0.243
Problem Solving	1.5175	2	62.4	0.227
Innovation	0.1054	2	61.7	0.900
Creativity	0.7932	2	60.6	0.457
Technology	0.5027	2	59.9	0.607
Critical Thinking	0.3246	2	61.3	0.724
Life and Career	0.0447	2	61.8	0.956

Age Differences in Perceived Skill Improvement

Research Question: What is the relationship between students' ages and their perceptions of how IZhO participation influences their development of 21st-century skills and aspirations for STEM careers?

The analysis categorized students into three groups based on their ages: Group 1 (13–14 years old), Group 2 (15–16 years old), and Group 3 (17–18 years old). A one-way ANOVA was conducted to evaluate whether age influenced students' perceptions of how participation in the International Zhautykov Olympiad (IZhO) contributed to their development of 21st-century skills.

As shown in Table 5, there were significant differences across the age groups for General Skills ($F(2, 15.8) = 6.326$, $p = .010$), Presentation Skills ($F(2, 24.6) = 8.543$, $p = .002$), Scientific Thinking ($F(2, 24.6) = 8.543$, $p = .002$), and Problem Solving Skills ($F(2, 19.2) = 6.696$, $p = .006$). These findings indicate that age plays a role in students' perceptions of skill improvement in these areas.

Table 5. One-Way ANOVA (Welch's)

	F	df1	df2	p
General skills	6.326	2	15.8	0.010
Presentation	8.543	2	24.6	0.002
Scientific Thinking/	8.543	2	24.6	0.002
Collaboration	1.183	2	13.8	0.336
Problem Solving	6.696	2	19.2	0.006
Innovation	1.085	2	14.1	0.364
Creativity	0.658	2	14.3	0.533
Technology	1.672	2	13.8	0.224
Critical Thinking	3.052	2	18.5	0.071
Life and Career	1.402	2	16.0	0.275

The post hoc analysis of mean values (Table 6) revealed that students in Group 1 (13–14 years old) rated the contribution of IZhO to their skill development significantly higher than those in Group 2 (15–16 years old) and Group 3 (17–18 years old) for General Skills, Presentation, Scientific Thinking, and Problem Solving. Notably, Group 3 (17–18 years old) had the second-highest mean scores for these skills, indicating a trend where younger students tend to perceive greater benefits from IZhO participation.

Table 6. Group Descriptives

	Age	N	Mean	SD	SE
	1	6	4.00	0.632	0.258
General skills	2	38	2.95	0.957	0.155
	3	59	3.41	0.949	0.124
Presentation	1	6	3.83	0.408	0.167

	Age	N	Mean	SD	SE
	2	38	2.82	1.182	0.192
	3	59	3.15	1.172	0.153
	1	6	3.83	0.408	0.167
Scientific Thinking	2	38	2.82	1.182	0.192
	3	59	3.15	1.172	0.153
	1	6	4.50	0.548	0.224
Problem Solving	2	38	3.58	1.177	0.191
	3	59	3.54	1.179	0.154

These results suggest that younger students, particularly those in Group 1, perceive the greatest impact of the Olympiad on their skill development, which could reflect differences in their learning needs, experiences, or aspirations compared to older students.

School Type Differences in Perceived Skill Improvement

The research question, "Which type of school reports the highest perceived benefit from participating in the IZhO Olympiad regarding skill development and STEM career aspirations?" was addressed by categorizing schools into three groups: Pr (Private schools), P (Public schools), and V (Vocational schools). A one-way ANOVA was conducted to evaluate whether school type significantly influenced students' perceptions of how IZhO participation contributed to their development of 21st-century skills.

The analysis revealed that among the evaluated skills, only the perception of improvement in technology showed a statistically significant difference across school types, as indicated by the p-value (p=0.037; see Table 7).

Table 7. One-Way ANOVA (Welch's)

	F	df1	df2	p
General Skills	0.146	2	43.6	0.864
Presentation	1.836	2	40.3	0.172
Scientific Thinking	1.836	2	40.3	0.172
Collaboration	0.122	2	44.6	0.886
Problem Solving	0.635	2	41.6	0.535
Innovation	1.939	2	43.2	0.156
Creativity	0.603	2	41.2	0.552
Technology	3.577	2	41.5	0.037
Critical Thinking	1.004	2	43.2	0.375
Life and Career	1.100	2	42.3	0.342

The descriptive statistics (Table 8) further demonstrated that students from vocational schools reported the highest mean scores for perceived improvement in technology (M=3.00, SD=1.487), followed by public schools (M=2.59, SD=1.359), and private schools (M=2.00, SD=1.069). These results highlight that students from vocational schools felt the greatest benefit from IZhO participation in developing technology-related skills.

Table 8. Group Descriptives

	School type	N	Mean	SD	SE
	Pr	22	2.00	1.069	0.228
Technology	P	61	2.59	1.359	0.174
	V	20	3.00	1.487	0.332

The Number of Olympiad Participations and Perceived Skill Improvement

Research Question: What is the relationship between the number of Olympiad participations and students' development of skills, and their aspirations for STEM careers?

To analyze this, we categorized the students into four groups based on their number of Olympiad participations: 1) those who participated 1-10 times, 2) those who participated 10-20 times, 3) those who participated 20-30 times, and 4) those who participated more than 30 times (see Table 9). A one-way ANOVA was conducted to evaluate whether the number of Olympiad participants significantly influenced students' perceptions of how participation in the International Zhautykov Olympiad (IZhO) contributed to their development of 21st-century skills. The p-value for the analysis indicates that only Critical Thinking demonstrated a significant difference (p=0.033).

Table 9. **One-Way ANOVA (Welch's)**

	F	df1	df2	p
General Skills	0.942	3	26.4	0.435
Presentation	0.275	3	25.5	0.843
Scientific Thinking	0.275	3	25.5	0.843
Collaboration	0.767	3	25.2	0.523
Problem Solving	0.679	3	25.3	0.573
Innovation	2.054	3	24.5	0.133
Creativity	2.638	3	24.7	0.072
Technology	0.926	3	25.7	0.442
Critical Thinking	3.410	3	24.4	0.033
Life and Career	0.542	3	24.7	0.658

Table 9 presents the detailed results of the ANOVA. To further examine the group differences, the mean values for Critical Thinking were analyzed. The first and third groups had nearly identical mean scores (M=3.74 for group 1 and M=3.71 for group 3), indicating similar perceptions regarding their Critical Thinking development (see Table 10).

Table 10. Group Descriptives

	Number of Participation to Olympiad	N	Mean	SD	SE
Critical Thinking	4	32	3.03	1.177	0.208
	3	7	3.71	1.496	0.565
	2	25	2.88	1.424	0.285
	1	38	3.74	1.032	0.167

Factors Influencing Students' STEM Career Interests

To define the main factors affecting IZhO participants' interest in a STEM career, we asked about their future major choice. Here, analyzing students' responses, we defined three categories of students' future majors: STEM, Non-STEM, and Not-decided. In the STEM category, we included any science, technology, engineering, and math majors. For the Non-STEM category, we included humanities majors, such as art, history, politics, and business. Also, 4 students from our sample intended to choose to Not-decided yet (Table 11).

Table 11. Majors that students possibly want to study in college (university)

Majors	Counts	% of Total	Cumulative %
STEM	95	92.2 %	92.2 %
Non-STEM	4	3.9 %	96.1%
Not-decided	4	3.9 %	100.0 %

Furthermore, Table 12 represents the frequency of students' responses to the question: "Write 5 factors, in order, that most affected your interest in a STEM career." Here, we once again carefully read students' responses and classified them based on the most frequent answers.

Table 12. Factors affected students STEM career interest.

Themes	Count (n)	% of Total
Family (parents and siblings)	15	15.8
Relatives, friends, and other people	7	7.4
School Staff (teachers and administration)	39	41
Personal ability (I am good at STEM)	17	17.9
Role model, literature, and Media (Internet TV)	17	17.9

Table 12 shows that school staff (teachers and administration) (41%) and family members (23.2%) are the most influential factors in students' future STEM careers. The majority of students claim that their science teachers motivated them to be involved in science and inspired them to pursue a STEM career. As another important factor in students' STEM career choice, students indicated relatives, friends, and other people (7.4% of responses). Additionally, Personal ability and STEM role models, scientific literature, and media were shown as the main factors in students' future career decisions (17.9% of responses).

The tenth question of the survey asked students about their beliefs regarding how participation in IZhO influenced their career interests. More than half of the sample (55 students) believe that IZhO reinforced their decision to pursue a STEM major. 41 students believe that participation in IZhO did not influence their decision about a future STEM career, while 4 students believe that IZhO changed their decision, and 3 students claim that IZhO made them confused about a future STEM career.

Discussion

This study investigated high schoolers' views about skill growth plus STEM job goals shaped via involvement within the International Zhautykov Olympiad (IZhO). The findings show how gender differs, age varies, subjects specialize, school types exist, also repeated participation influences the shaping of these perceptions.

For female students, there were reports of more improvements to Presentation, Scientific Thinking, and Collaboration skills than for their male counterparts as well, which is revealing of meaningful gender-based differences within perceptions of skill development. These results do suggest that female students may appreciate the Olympiad's opportunities much more. The Olympiad allows them to present and refine these skills now. This discovery agrees with older research for it says helpful settings matter to female STEM students since those build skill and trust. Exploring underlying factors could research these disparities further. Differences based on gender in the prior experiences or in the cultural expectations can be examples of those factors.

Contrary to expectations, students focusing on STEM fields like Mathematics, Physics, Informatics said they had nearly the same skill gains after IZhO participation. Because of how it lacks any important variation, the Olympiad offers up a broadly helpful platform. The platform develops for the 21st-century the skills across the STEM fields. IZhO's versatility is stressed via these results at fostering necessary skills like Critical Thinking and Problem Solving regardless of subject specialization.

Age was found to have an influence on student perceptions particularly when considering Problem Solving, Scientific Thinking, Presentation Skills, and General Skills. Younger students of ages thirteen to fourteen reported higher perceived benefits. Older classmates did not state likewise great gains. This trend may reflect the greater sensitivity of younger students to differences in baseline skill levels or new learning experiences. Also, it is possible for older students to view their progress with more criticality because they may have matured in academics or have experienced some other STEM opportunities. The results show a need for customized Olympiad events for age groups. Tailoring maximizes the impact of the experiences.

When we analyzed by school type, we found students in vocational schools improved Technology skills more than those in public and private schools. This finding shows that vocational education fosters learning that is both practical and is technology-oriented. The curricula for these school types could also reflect some emphasis differences with technological skills. For future initiatives, they could consider leveraging vocational schools so that they strengthen technology education in order to improve skill development opportunities for each of the participants.

The study also examined the relationship of the number of Olympiad participations along with skill development. The researchers found only Critical Thinking showed meaningful differences between groups. Students whose participation was moderate (10–20 times) interestingly reported higher perceived improvements than students with other rates. This finding suggests a plateau effect where frequent participation could lead to diminishing returns in perceived skill enhancement.

Further research is needed to understand how repeated participation shapes students' experiences and skill development trajectories.

The findings highlight the potential of Olympiads such as IZhO to inspire STEM career aspirations as well as contribute to the development of 21st-century skills. The results suggest that in the event programs target and intervene, such as by additionally supporting older students or stressing technology skills across all of school types, they could be more effective at it. For ensuring equitable benefits for male as well as female participants, gender-specific strategies may be warranted. These are strategies that can help provide for fair outcomes.

Our analysis shows IZhO participation affects students' future careers through career interest greatly. A majority of all students reported a desire for pursuing STEM fields at college or at university since that participation within science competitions had an influence that was long-term. Earlier research has shown how Science Olympiads transform students' long-term career interests together with ambitions in STEM (Smith et al., 2021). Such research supports this conclusion. In general, such findings remain consistent through all research regarding Science Olympiads, plus they validate that idea which states these events encourage academic success, personal growth, and professional development.

Though this study provides valuable perceptions, several limitations must be acknowledged. The generalizability of findings to more broad populations may be limited by the representative sample size that was used. Also, self-reported data use may cause bias since subjects think or remember. Future research could address these limitations via longitudinal designs so objective skill development measures may be incorporated. The impact from Olympiad participation on cultural or regional differences could be explored too.

Conclusion

Overall, this study underscores how Olympiad participation greatly helps to foster critical skills so as to shape STEM career aspirations among high school students. Educators and policymakers can maximize all of the benefits of such programs by addressing all of the unique needs of different demographic groups. Various educational contexts also allow them to use strengths as they hope to prepare for a STEM workforce with more skills and motivation.

Educational settings can benefit greatly in practical and theoretical ways from results of this study. For educators, policymakers, or other stakeholders, a program integrating Olympiad-style problems into a regular school curriculum can be designed. Since it has practical application in education and real implications, the program can foster critical thinking and problem-solving skills in students. For building of their confidence and for motivation in pursuing a STEM career, Olympiads participation of students should actively be promoted. Also, focused assistance for marginalized groups may help guarantee wider access to these key experiences, as they ready pupils with the vital modern skills useful for later achievement. In theory, this study is an improvement to the literature that exists on extracurricular activities because the study shows just how structured environments that are also competitive like science Olympiads can improve intrinsic motivation as well as self-efficacy plus important skills, so competition-based learning is suggested to be a component of great value within STEM education models.

For obtaining quantitative data from Kazakhstan along with a few other countries, the research was limited to a specific cohort of participants. Future research could expand on these findings by examining a more diverse population and exploring the long-term impact of participation in science Olympiads on career trajectories and skill development. Moreover, it is also interesting to investigate how students' attitudes toward participating in the IZhO are influenced by whether they receive valuable prizes and medals or no recognition at all. Understanding this dynamic could shed light on the role of external rewards in shaping students' motivation and engagement in science competitions. In conclusion, this study demonstrates the enormous influence that participation in scientific Olympiads may have on students, ranging from increasing their self-esteem and critical thinking abilities to sparking a lifelong interest in STEM careers. This study emphasizes the relevance of incorporating such Olympiads into school curriculum by presenting empirical data on how these contests help to the development of critical 21st-century skills. The findings not only add to our understanding of effective educational approaches, but also provide vital insights for developing future educational policies and practices that will better support and inspire the next generation of scientists and innovators.

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БОЛАШАҚ ҒАЛЫМДАРДЫ ҚАЛЫПТАСТЫРУ: IZHO ХАЛЫҚАРАЛЫҚ ОЛИМПИАДАСЫНЫҢ ЖОҒАРЫ СЫНЫП ОҚУШЫЛАРЫНЫҢ STEM БАҒЫТТАРЫНА ҚЫЗЫҒУШЫЛЫҒЫ МЕН ДАҒДЫЛАРЫН ДАМЫТУҒА ЫҚПАЛЫ

Аңдатпа. Бұл зерттеу Халықаралық Жәутіков олимпиадасына (IZhO) қатысудың мектеп оқушыларының XXI ғасыр дағдылары мен STEM мамандықтарына қызығушылығына әсерін зерттейді. Аралас әдістеме (mixed-methods) негізінде жүргізілген зерттеу жыныстық айырмашылықтарды, STEM салалары арасындағы ерекшеліктерді, жас ерекшеліктерін, мектеп түрінің ықпалын және қатысу жиілігінің әсерін талдайды. Зерттеу нәтижелері бойынша қыз балалар Ер балаларға қарағанда Презентация, Ғылыми ойлау және Ынтымақтастық дағдыларының анағұрлым жоғары дамығанын көрсетті. STEM бағыттары арасында айтарлықтай айырмашылық байқалмады, бұл IZhO-ның Математика, Физика және Информатика оқушылары үшін бірдей тиімділігін көрсетеді. Жас ерекшелігіне қарай талдау нәтижесінде 13–14 жастағы оқушылар Жалпы дағдылар, Презентация және Мәселені шешу салаларында жоғары өсімді байқаған. Кәсіптік мектеп оқушылары Технология дағдылары бойынша ең жоғары нәтижелер көрсетті. Сонымен қатар, Олимпиадаға орташа деңгейде (10–20 рет) қатысқан оқушыларда Сыни ойлау дағдысы айтарлықтай жақсарған. Бұл нәтижелер Олимпиадаға қатысудың маңызды дағдыларды дамытудағы және STEM саласына қызығушылықты арттырудағы әлеуетін көрсетеді. Сондай-ақ, жас және жыныс ерекшеліктерін ескеретін арнайы тәсілдер, мектеп түріне бейімделген әдістер қажет екенін және бірнеше рет қатысудың мотивациясын сақтауға бағытталған стратегияларды әзірлеудің маңыздылығын айқындайды. Зерттеу STEM байқауларының болашақтағы академиялық және кәсіби табысқа дайындаудағы рөлін атап көрсетеді.

Түйінді сөздер: STEM білім беру, XXI ғасыр дағдылары, Олимпиадаға қатысу, дағдыны дамыту, гендерлік айырмашылықтар, STEM мансаптары.

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ФОРМИРОВАНИЕ БУДУЩИХ УЧЁНЫХ: РОЛЬ МЕЖДУНАРОДНОЙ ЖАУТЫКОВСКОЙ ОЛИМПИАДЫ (IZHO) В ФОРМИРОВАНИИ ИНТЕРЕСА К STEM И РАЗВИТИЮ НАВЫКОВ У СТАРШЕКЛАССНИКОВ

Аннотация. Данное исследование посвящено анализу влияния участия в Международной Жәутыковской олимпиаде (IZhO) на восприятие школьниками развития навыков XXI века и стремления к карьере в STEM-сфере. С использованием смешанных методов (mixed-methods) исследуются гендерные различия, специфика по направлениям STEM, возрастные тренды, влияние типа школы и эффект многократного участия. Результаты показали значительные гендерные различия: девочки сообщили о большом прогрессе в навыках презентации, научного мышления и сотрудничества по сравнению с мальчиками. Между направлениями STEM существенных различий не выявлено, что указывает на равную эффективность IZhO для учащихся по математике, физике и информатике. Анализ по возрасту показал, что учащиеся 13–14 лет отмечают больший рост навыков, особенно в общих умениях, презентации и решении проблем. Ученики профессиональных колледжей продемонстрировали наивысшие показатели в технологических навыках по сравнению с учащимися государственных и частных школ. Кроме того, умеренная частота участия (10–20 раз) была связана с наибольшим прогрессом в критическом мышлении. Эти результаты подчеркивают потенциал участия в олимпиадах для развития ключевых навыков и стимулирования интереса к STEM-карьере.

Также подчеркивается важность индивидуализированных подходов с учетом возраста и пола, а также разработка стратегий по поддержанию мотивации при повторном участии. Исследование подчеркивает значимость STEM-соревнований для подготовки учащихся к академическому и профессиональному успеху.

Ключевые слова: STEM-образование, навыки XXI века, участие в олимпиадах, развитие навыков, гендерные различия, STEM-карьера.

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