“Open science and youth creativity: Evidence from Ukrainian university students”

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OPEN SCIENCE AND YOUTH CREATIVITY: EVIDENCE FROM UKRAINIAN UNIVERSITY STUDENTS

Abstract

Amid growing global challenges such as technological change and socio-economic uncertainty, fostering youth creativity has become vital for sustainable development. In Ukraine, open science provides a promising pathway to develop key competences like creativity, critical thinking, and collaboration, essential for navigating ongoing social and educational transformation. This study aims to investigate the relationship between Ukrainian young people's engagement with open science practices and their creative development across academic disciplines and educational levels. Drawing on data from a nationwide survey of 2,250 Ukrainian university students (Bachelor, Master, and Ph.D.), this study applies non-parametric methods to analyze how young people engage with open science. The results show that engagement with open science practices among Ukrainian students varies significantly by both level of education and field of study. Ph.D. students report the highest frequency of participation (median = 4.0 on a 5-point scale), significantly more than Bachelor's and Master's students (Kruskal-Wallis $\chi^2 = 44.92$, $p < 0.001$). They also rate mentorship and collaborative research as more effective for creativity (e.g., mentorship: $p = 0.00008$ between Bachelor and Master levels). Disciplinary differences are most evident in the perceived effectiveness of webinars ($\chi^2 = 31.69$, $p = 0.0002$) and collaborative research ($\chi^2 = 23.34$, $p = 0.0055$), with students from engineering and life sciences showing the highest appreciation. These differentiated patterns confirm that the creative development potential of open science is powerfully shaped by students' academic stage and disciplinary background.

Keywords innovation skills, youth creativity, transformational competences, open science, higher education

INTRODUCTION

In accelerating technological change and increasing global complexity, the 21st century values innovation, adaptability, and problem-solving as foundational drivers of societal progress. Within this framework, the development of transformational competences, particularly creativity, collaboration, and critical thinking, has emerged as a strategic imperative for empowering young people to engage meaningfully with contemporary challenges. The Organisation for Economic Co-operation and Development (OECD) has identified these competences as essential for enabling individuals to "create new value, reconcile tensions and dilemmas, and take responsibility," emphasizing their relevance for navigating uncertain and interdependent environments (OECD, n.d.). Similarly, UNESCO (2021a) underscores the urgency of equipping young people with creative and collaborative capacities that foster resilience, curiosity, and agency in the face of global transformation. These competencies support individual adaptability and contribute to broader sustainable and inclusive development goals.

In this regard, open science offers a compelling and underutilized framework for cultivating creativity among young people. With its emphasis on transparency, inclusiveness, and the co-creation of knowledge, open science promotes key conditions for creative engagement. UNESCO (2021b) explicitly acknowledges open science as a vehicle for developing transformational competences by facilitating interdisciplinary collaboration, critical inquiry, and participatory research processes. Open science strengthens the conditions that underpin creative development by enabling inclusive access to scientific knowledge and engaging diverse actors in shared problem-solving. The European Commission (n.d.) further affirms this potential, noting that practices such as open access publishing, citizen science, and open data advance scientific innovation and provide young people with practical opportunities to participate in collaborative knowledge production. These mechanisms help foster a mindset of experimentation and innovation essential for young people to thrive in a knowledge-based and resilient society. Integrating open science into broader youth development agendas can thus catalyze creativity and empower the next generation of innovators.

Given the growing importance of creativity as a core driver of innovation and resilience, understanding how open science can cultivate youth capacities is timely and essential.

1. LITERATURE REVIEW

Creativity among youth is increasingly recognized as a fundamental driver of socio-economic resilience and innovation. Its development has gained urgency in light of global shifts such as rapid technological change, post-pandemic restructuring, and, in Ukraine's case, the profound socio-political disruption caused by the ongoing war. These contexts underscore the strategic need for competences that enable individuals to generate novel solutions, adapt to uncertainty, and contribute to sustainable recovery and transformation.

Transformational competences, including creativity, collaboration, adaptability, and critical thinking, are critical to fostering innovation and inclusive growth. These competencies underpin competitive advantage, particularly in systemic shocks and institutional fragility environments. Studies across multiple sectors confirm that innovation-driven development increasingly depends on the capacity to cultivate such skills at early stages of education and employment. For example, the ability of hi-tech SMEs to grow under Fourth Industrial Revolution conditions has been linked to creative potential and adaptability within institutional frameworks (Antoniuk et al., 2017; Sitnicki et al., 2022), while innovation in public health and sustainability domains has been shown to rely on leadership, learning systems, and knowledge management (Tessema, 2025; Alemu, 2025). The strategic integration of competence-based approaches is also required at the project design level, particularly for early-stage innovation initiatives that demand tailored decision-making models (Mandryka et al., 2023). Furthermore, the effectiveness of innovation ecosystems is shaped by geographic and institutional proximity, which supports localized knowledge spillovers and entrepreneurial creativity (Zahidi et al., 2025).

The war in Ukraine has amplified socio-economic precarity among young people, deepening the urgency to support creative capacities that enable adaptive labor strategies and civic resilience. Socio-economic instability has been identified as a key barrier to creative employment (Fónai & Fedor, 2023; Hidayat et al., 2023), while creative jobs have emerged as a potential resource for economic recovery in war-affected societies (Marshavin, 2024; Sitnicki et al., 2024). Additionally, shifting youth behaviors, such as increased interest in the sharing economy, reflect a generational turn toward innovation-oriented value systems, especially under disruptive conditions (Zhghenti & Kapanadze, 2024).

The digital environment is central to shaping youth creativity and innovation. Big data applications and data-centric organizational cultures foster product and process innovation (Almarashdah et al., 2025; Mursalov et al., 2023), while ethical and transformational leadership

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are shown to encourage innovative behavior within digitalized institutions (Alkhodary, 2025; Bian & Wang, 2024; Bunkaewsuk et al., 2024; Suliati et al., 2025). Individual and organizational factors also play a pivotal role in influencing innovative work behavior, including those found in the private sector, where empirical research highlights the role of internal dynamics in shaping creativity (Hai Yen et al., 2025a). Moreover, academic environments are affected by knowledge-hiding behaviors, which can undermine creative performance among students (Hai Yen et al., 2025b). Broader systemic analyses also highlight the importance of responsible AI development, particularly in ensuring that digital creativity is aligned with social values and ethical standards (Memarian & Doleck, 2024; Yarovenko et al., 2023).

Open science has emerged as a key institutional framework capable of activating creative potential, particularly through co-creation, transparency, and collaborative learning. University–industry partnerships, science-business cooperation, and participatory approaches have been shown to drive institutional innovation, with higher education institutions acting as central hubs in this ecosystem (Artyukhov et al., 2023; Kuzior et al., 2024a, 2024b). Participatory tools such as student involvement in quality assurance mechanisms have also been linked to enhanced creativity at the institutional level (Liuta et al., 2021). Data-driven and collaborative education models further support this dynamic, allowing young people to engage with innovation as recipients and active contributors (Artyukhov et al., 2024; Didenko et al., 2022, 2023).

The creative economy literature reinforces the relevance of human capital and entrepreneurship as the foundation of emerging technology ecosystems. Innovation-based economic models, particularly those embedded in industrial and international domains, emphasize creativity as a factor of competitiveness and resilience (Perevozova et al., 2019a, 2019b; Ziane et al., 2025). Human capital, in particular, is positioned as a structural pillar of long-term socio-economic transformation (Petrova & Pereira, 2024), while institutional trust facilitates open innovation among medium-high-tech enterprises (Runiewicz-Wardyn & Winogradska, 2023). Dual-path frameworks, combining creative destruction with incremental reform, remain relevant for innovation governance, especially in contexts of post-crisis recovery (Kilgour & Melnyk, 2011).

Creativity does not arise in a vacuum but is mediated by individual and organizational factors. Psychological antecedents such as perceived job insecurity or social dynamics can stimulate or suppress creativity depending on the environment (Sugiono, 2025; Baloch & Paoletti, 2025). Organizational dependency on expert knowledge may also limit creative autonomy, especially in rigid decision-making structures (Raišienė & Raišys, 2024).

Financial and digital literacy are also increasingly recognized as key enablers of creativity, especially among youth. The quality of scientific activity and financial competence has been empirically linked to broader measures of socio-economic development and inclusion (Didenko et al., 2022, 2023), while digital financial skills support youth engagement in entrepreneurial and investment activities (Khan et al., 2025; Putri Susanto et al., 2024). Addressing information asymmetries through ICT platforms contributes to a more inclusive knowledge economy and supports creativity in decentralized systems (Ivashchenko et al., 2017).

Innovative governance frameworks increasingly integrate systemic and digital complexity. From the perspective of socio-natural resilience, creative governance is seen as a form of anti-entropic potential (Melnyk, 2020), while the role of intelligent finance and complex systems is explored in building adaptive, knowledge-based institutions (Njegovanović, 2023, 2024; Sitnicki, 2018). Bibliometric evidence confirms a growing convergence between digital transformation and creativity in strategic innovation management (Ponomarenko et al., 2024), while societal perceptions of artificial intelligence reflect its dual potential as both a creative enabler and a source of concern (Yarovenko et al., 2024).

The relevance of open science within this broader landscape is further underscored by its role

in international research collaboration, ethical digitalization, and science democratization. Institutional mechanisms supporting open access and collaborative knowledge production enhance scientific innovation and societal resilience (Kuzior et al., 2024; European Commission, n.d.; UNESCO, 2021b). Ethical and regulatory frameworks for AI and open systems remain essential for balancing innovation and accountability in the creative economy (Schinello, 2025).

The reviewed literature presents a multidimensional landscape in which open science, digitalization, and youth creativity intersect across institutional, psychological, and economic domains. These studies collectively affirm that fostering creativity through open science is a viable and necessary strategy for driving innovative and sustainable development, particularly in crisis-affected contexts such as Ukraine, where educational, social, and economic systems require transformation through inclusive and participatory knowledge practices.

This study aims to investigate the relationship between Ukrainian young people's engagement with open science practices and their creative development across academic disciplines and educational levels. It seeks to examine the extent to which open science methods are perceived and utilized by young people, and how these practices influence their motivation, idea generation, and overall creative potential within higher education.

Research Hypotheses:

H1: There is a significant difference in the use of open science practices across different levels of education.

H2: Young people who agree that open-access publications help them generate ideas report higher levels of motivation and creativity from open science initiatives.

H3: The perceived effectiveness of various open science practices differs according to the level of study.

H4: The perceived effectiveness of various open science practices differs across academic fields.

2. METHODOLOGY

2.1. Study design and participants

This study explores the connection between young people's engagement with open science and their creativity in higher education. A structured questionnaire was developed to gather quantitative data on young people's experiences with open science practices, including perceived benefits and challenges to implementation. The research team developed the questionnaire based on a review of existing literature on youth creativity, open science, and educational innovation. Its content and structure were validated with academic experts and student representatives from multiple Ukrainian universities (Appendix A). The survey targeted young people at different stages of their academic journey, undergraduate, master's, and doctoral levels, across a wide range of academic disciplines.

The data were collected anonymously via Google Forms between September 20 and October 20, 2024. The survey reached young people throughout Ukraine, except for the temporarily occupied territories. Although the survey did not explicitly collect regional identifiers, efforts were made to ensure broad geographical coverage across Ukraine (excluding temporarily occupied territories) by disseminating the questionnaire through student networks in multiple regions and institutions.

A cross-sectional survey design yielded responses from 2,250 participants representing fields such as natural sciences, social sciences, engineering, humanities, and life sciences. The sample included 1,533 bachelor's, 401 master's, and 316 Ph.D. Students, enabling comparisons across levels of academic progression. To ensure the clarity and validity of the questionnaire, internal validation was conducted with input from representatives of different Ukrainian universities. The initial pilot testing helped identify ambiguities or problematic items. Particular attention was paid to students' understanding of questions, difficulties in responding, and the time required to complete the survey. Based

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Table 1. Distribution of respondents by field of study, compared to the national proportions

Field of Study	Proportion of Students (%)	Minimum Required Respondents	Actual Respondents
HUM: Humanities and Arts	12%	128	281
SOC: Social Sciences and Law	15%	160	389
ECO: Economic Sciences	15%	160	746
LIF: Life Sciences	9%	96	112
MED: Medicine and Veterinary Sciences	10%	107	109
MAT: Mathematics	3%	32	33
CHE: Chemistry	5%	53	116
PHY: Physics	4%	43	46
ENG: Information Technology & Engineering	22%	235	303
ENV: Environment and Geosciences	5%	53	115

on this feedback, the questionnaire was revised and retested with a second pilot group. This process ensured the final instrument was clear, comprehensible, and contextually appropriate.

Cochran's formula (Heinisch, 1965) was applied to determine the minimum required sample size for a population of higher education students in Ukraine to ensure the sample was representative. Assuming a 95% confidence level, a 5% margin of error, and a conservative estimate of population proportion ($p = 0.5$), the formula yielded a minimum sample size of approximately 385 participants. With 2,250 valid responses collected, the achieved sample significantly exceeds this threshold, providing strong statistical power and ensuring robust generalizability of the findings across educational levels and academic disciplines. This large and diverse sample enhances the reliability and external validity of the study results.

This study employed proportional sampling based on official statistics regarding the distribution of students across levels of higher education in Ukraine. According to national enrolment data, the proportional breakdown was as follows: bachelor's degree – 63% (minimum 672 participants), master's degree – 32% (minimum 341 participants), and postgraduate (Ph.D.) degree – 6% (minimum 64 participants). The actual sample met and exceeded these minimum requirements across all levels. Table 1 presents the distribution of respondents by field of study, compared to the national proportions.

As shown, the achieved sample satisfies proportional representation requirements across disciplines.

2.2. Survey variables

To explore the relationship between open science practices and student creativity, the study employed a structured survey instrument composed of multiple items related to the frequency, perception, and effectiveness of open science methods. Variables captured a range of dimensions, including demographic background (level and field of study), frequency of open science usage, perceived benefits, and evaluations of specific open science tools.

All substantive responses were recorded using Likert-scale formats to reflect the degree of agreement, frequency, or perceived effectiveness. Response options ranged from five to six ordinal categories (e.g., Never to Very often, Disagree to Agree, Ineffective to Effective), as well as the inclusion of "I do not know" to capture uncertainty or unfamiliarity.

Table 2. Variables and their descriptions

Source: Developed by authors.

Variable	Description
x1	Education level (Bachelor, Master, Ph.D. student)
x2	Field of study (Chemistry, Economics, Engineering, etc.)
x3	Frequency of open science usage (Never to Very often)
x4	Frequency of creativity enhancement through open science (Never to Always)
x20	Agreement that open access helps idea generation (Disagree to Agree)
x22	Motivation and creativity derived from open science initiatives (Disagree to Agree)
x23-x30	Perceived effectiveness of specific open science methods in developing creativity: collaborative research (x23), webinars/online courses (x24), mentorship/coaching (x25), hackathons (x26), peer learning (x27), knowledge sharing (x28), collaboration platforms (x29), other methods (x30)

Table 3. Distribution of responses by variable

Source: Authors' calculation in R Studio.

Variable	Characteristics						Σ
x1	Bachelor		Master		Ph.D. Student		Σ
	1533		401		316		2,250
x3	Never	Rarely	Sometimes	Often	Very often		
	18	100	580	1018	534		2,250
x4	Never	Rarely	Sometimes	Often	Always	I do not know	Σ
	8	68	528	1,145	463	38	2,250
x20, x22	Disagree	Rather disagree	Neutral	Rather agree	Agree	I do not know	Σ
x20	5	17	200	715	1296	17	2,250
x22	31	46	602	702	790	79	
x23-x30	Ineffective	Rather ineffective	Neutral	Rather effective	Effective	I do not know	Σ
x23	17	22	299	751	1,134	27	2,250
x24	18	34	307	816	1,057	18	
x25	32	36	489	681	936	76	
x26	32	52	575	745	715	131	
x27	23	39	394	790	978	26	
x28	7	18	227	654	1,315	29	
x29	7	20	300	714	1,173	36	
x30	7	14	706	472	706	345	

Table 3 presents the distribution of responses across key survey variables, including demographic characteristics (e.g., field and level of study) and perceptions related to open science practices. The table reflects Likert-type scales and categorical responses, allowing for detailed descriptive and inferential analysis across educational levels and academic disciplines. This distribution provided the foundation for the non-parametric statistical tests employed in the study.

2.3. Data analysis

Data collected through the survey were cleaned, coded, and analyzed using R Studio. Descriptive statistics were computed to summarize the participants' demographic characteristics and responses to key variables. This included frequencies and percentages for categorical variables, particularly those based on Likert-scale measurements.

Non-parametric statistical methods were employed to assess differences across education levels and fields of study due to the ordinal nature of most variables and the non-normal distribution of responses. Specifically, the Kruskal-Wallis H test was used to determine whether statistically significant differences existed between three or more independent groups (e.g., bachelor's, master's, and Ph.D. Students; or academic disciplines) concerning their engagement in open science and perceptions of its effectiveness.

When the Kruskal-Wallis test indicated significant results ($p < 0.05$), post-hoc pairwise comparisons were performed using Dunn's test with Bonferroni correction to identify where the specific differences occurred between groups.

Spearman's rank correlation was applied to measure the strength and direction of associations between ordinal variables, such as agreement with the usefulness of open access and perceived motivation from open science initiatives.

In addition to statistical testing, data visualization techniques (e.g., boxplots, heatmaps, and bar charts) were utilized to support interpretation and visually represent group differences and response patterns. These graphical outputs were produced using the ggplot2 package in R.

All analyses adhered to a significance level of $p < 0.05$, and missing data were handled through casewise deletion for each specific test or plot.

2.4. Ethical considerations

The study adhered to ethical standards for research involving human participants. Participation in the survey was entirely voluntary, responses were collected anonymously, and informed consent was obtained from all respondents before participation. As the re-

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search did not involve sensitive personal data or vulnerable groups, formal approval by an ethics committee was not required under national guidelines.

3. RESULTS

There is a significant difference in open science usage between levels of education.

A Spearman rank-order correlation was conducted to assess the relationship between young people's level of education and their frequency of using elements of open science. The analysis revealed a positive and statistically significant correlation between education level and open science usage ($\rho = 0.13$, $p < 0.001$). This suggests that young people with higher education levels (e.g., Master's and Ph.D.) tend to report more frequent use of open science practices. Although the effect size is small, the relationship is robust across the sample ($N \approx 2{,}000$).

While the strength of the association is relatively weak ($\rho = 0.13$), the significance indicates a consistent trend that may be influenced by curriculum exposure, research involvement, or digital literacy, which increase at higher academic levels.

Figure 1 illustrates the relationship between young people's level of education (Bachelor, Master, Ph.D.) and their self-reported frequency of using open science elements (e.g., open data, open code, open educational resources) during academic tasks.

The fitted trend line shows a slight positive association, indicating that higher levels of education are associated with more frequent use of open science practices. This trend is supported by the results of a Spearman rank correlation analysis, which revealed a statistically significant, albeit small, positive correlation ($\rho = 0.13$, $p < 0.001$). While the effect size is modest, the consistency of the pattern across the data suggests that more advanced young people, particularly those at the postgraduate level, may be more exposed to or comfortable with open science tools and methods.

Figure 2 presents a boxplot illustrating the distribution of open science usage frequency across three levels of education: Bachelor's, Master's, and Ph.D. The results show that young people at all levels report regular engagement with open science practices, though a slight upward shift in frequency is observed with increasing education level. Ph.D. Students display the highest median and interquartile range, suggesting they engage

Source: Authors' calculation in R Studio.

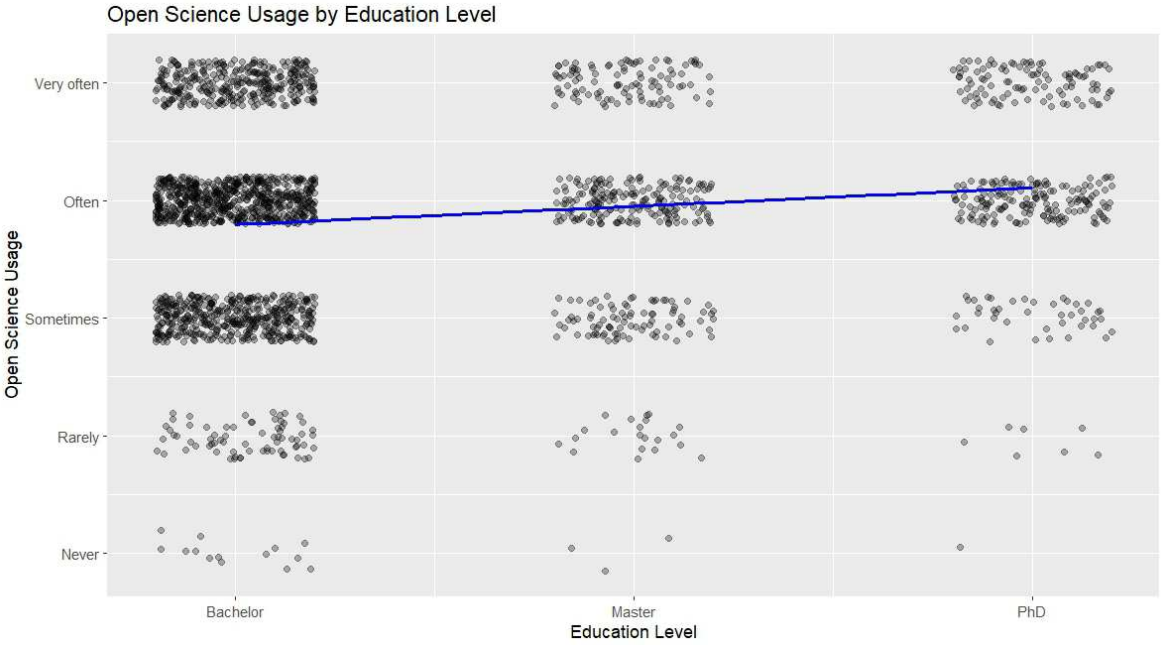

Figure 1. Relationship between education level and frequency of open science usage

Source: Authors' calculation in R Studio.

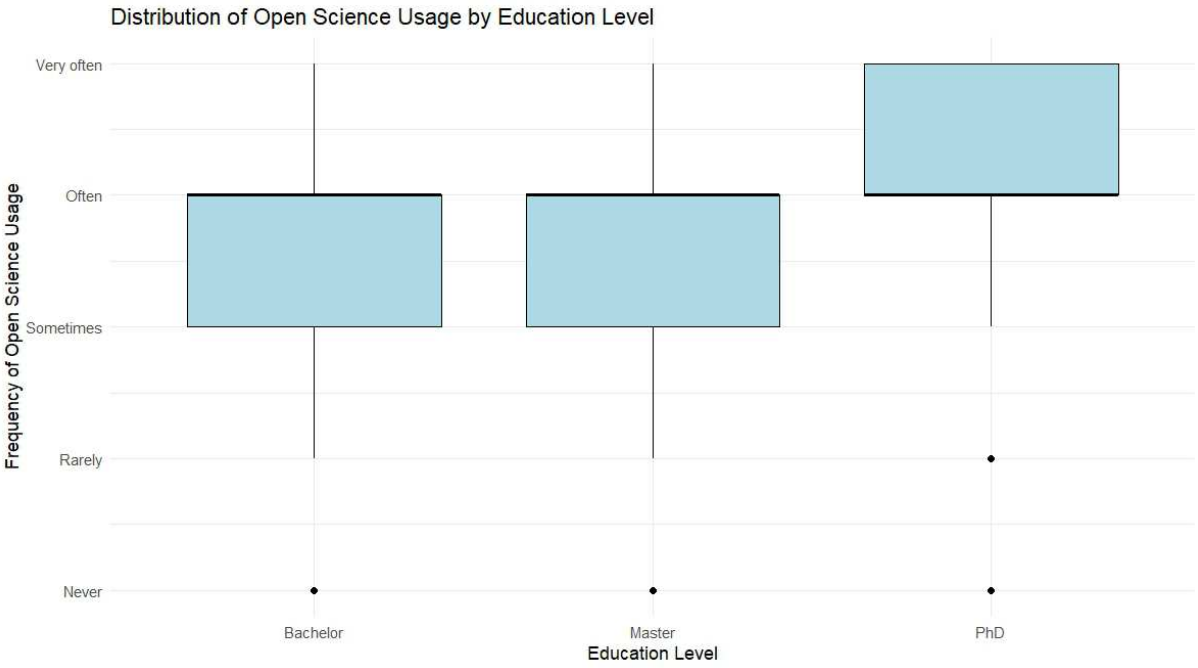

Figure 2. Distribution of open science usage by education level

with open science more frequently than their Master's and Bachelor's counterparts. This trend is consistent with the previously reported positive Spearman correlation ($\rho = 0.13$, $p < 0.001$), indicating that higher education levels are modestly but significantly associated with greater use of open science elements in academic tasks – the spread and presence of outliers, particularly among Ph.D. Students, highlight individual variability and underscore the overall upward trend.

A Kruskal-Wallis rank sum test was conducted to determine whether there were statistically significant differences in the frequency of open science usage among young people with different education levels (Bachelor's, Master's, and Ph.D.). The test revealed a statistically significant difference between the groups, $\chi^2(2) = 44.92$, $p < 0.001$. This indicates that at least one education level group differs significantly in how frequently they report using open science elements (e.g., open data, open code, educational resources) in their academic work. Given the ordinal nature of the data and the non-parametric approach, these results suggest a meaningful trend in which higher levels of education may be associated with increased engagement in open science practices.

A post-hoc analysis using Dunn's test with Bonferroni correction was conducted to identify which specific education levels differed significantly in their frequency of open science usage, following a significant Kruskal-Wallis test. The results revealed statistically significant differences between Ph.D. Students and both Master's ($p < 0.001$) and Bachelor's students ($p < 0.001$), indicating that Ph.D. Students report a significantly higher frequency of using open science elements in their academic activities. The difference between Bachelor's and Master's students did not reach statistical significance after adjustment ($p = 0.064$), although the unadjusted result suggested a potential trend. These findings support the notion that engagement with open science practices increases academically, particularly at the doctoral stage.

Young people who agree that open-access publications help them generate ideas also report greater motivation and creativity from open science initiatives.

A Spearman rank-order correlation was conducted to assess the relationship between young people's agreement that open-access publications help generate new ideas and their reported motivation and creativity from open science initiatives. The results revealed a moderate, positive, statistically significant correlation between the two variables, $\rho = 0.37$, $p < 0.001$. This indicates that young peo-

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Source: Authors' calculation in R Studio.

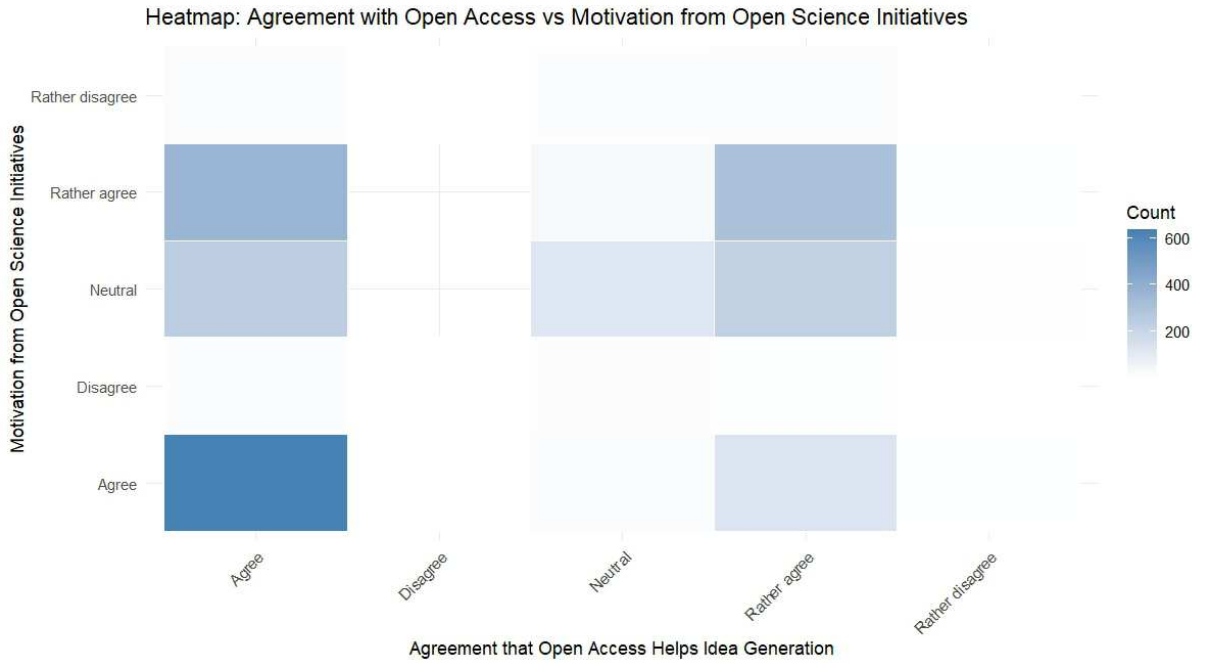

Figure 3. Heatmap of student agreement that open access helps idea generation vs. reported motivation from open science initiatives

ple who perceive open access to scientific publications as beneficial for idea generation are likelier to report higher motivation and creativity when participating in open science activities such as crowdsourcing projects. These findings suggest a meaningful connection between exposure to open-access resources and open science engagement's perceived value and impact on learning and innovation.

Figure 3 presents a heatmap showing the joint distribution of student responses regarding the perceived value of open access in generating ideas and their reported motivation and creativity resulting from open science initiatives.

The highest concentration of responses appears in the bottom-left quadrant, where young people who agree that open access supports idea generation also report high motivation from open science activities. The color intensity indicates a strong positive clustering along the diagonal, particularly in both variables' "Rather agree" and "Agree" categories. This pattern supports the results of the Spearman correlation ($\rho = 0.37$, $p < 0.001$), suggesting a meaningful and moderately strong association – young people who perceive greater benefits from open access tend to be more motivated by open science participation. This highlights the reinforcing nature of open science engagement across multiple dimensions of learning and creativity.

A Kruskal-Wallis rank sum test was performed to examine whether young people's reported motivation and creativity resulting from open science initiatives differed significantly depending on their agreement with the statement that open access publications help them generate new ideas. The test revealed a statistically significant difference across the five groups, $\chi^2(4) = 316.71$, $p < 0.001$. This indicates that young people's motivation for open science initiatives varies meaningfully based on how strongly they agree that open access supports idea generation. The finding supports the earlier correlation analysis and suggests that young people who perceive open access as intellectually beneficial are also more engaged and creatively stimulated by open science participation.

Following the Kruskal-Wallis test, a post-hoc Dunn's test with Bonferroni correction was conducted to identify specific group differences in young people's reported motivation from open science initiatives based on their level of agreement that open access publications help generate ideas (Table 4).

Table 4. Results of Dunn's post-hoc test comparing levels of agreement with open access benefits and motivation from open science initiatives

Source: Authors' calculation in R Studio.

No.	Comparison	Z-Score	Unadjusted *p*-value	Adjusted *p*-value (Bonferroni)	Significant
1	Agree – Disagree	3.29	0.00099	0.00988	Yes
2	Agree – Neutral	14.85	< 0.000001	< 0.000001	Yes
3	Disagree – Neutral	–0.71	0.475	1.00000	No
4	Agree – Rather agree	12.00	< 0.000001	< 0.000001	Yes
5	Disagree – Rather agree	–2.02	0.043	0.43301	No
6	Neutral – Rather agree	–7.13	< 0.000001	< 0.000001	Yes
7	Agree – Rather disagree	3.91	0.000094	0.00094	Yes
8	Disagree – Rather disagree	–0.96	0.336	1.00000	No
9	Neutral – Rather disagree	–0.65	0.514	1.00000	No
10	Instead, agree – Rather disagree	1.64	0.102	1.00000	No

Note: Significance based on Bonferroni-adjusted p-values ($p < 0.05$).

The results showed that young people who agreed with the benefits of open access reported significantly higher motivation than those who were neutral, somewhat agreed, disagreed, or strongly disagreed ($p < 0.01$ in all cases). Additionally, neutral young people showed significantly lower motivation than those who agreed ($p < 0.001$). After correction, no significant differences were observed between disagreeing and neutral groups, nor between somewhat disagreeing and other categories. These findings reinforce a graded, positive relationship: as agreement with the benefits of open access increases, so does motivation and creativity from open science initiatives.

The perceived effectiveness of various open science practices differs depending on the student's level of study.

Kruskal-Wallis tests were conducted to assess whether young people's level of education (Bachelor's, Master's, Ph.D.) significantly influenced their perceived effectiveness of various open science practices in supporting creativity. The results (Table 5) showed significant differences across education levels for collaborative research ($p = 0.0018$), webinars ($p = 0.018$), mentorship ($p < 0.001$), hackathons ($p < 0.001$), peer learning ($p = 0.0099$), and other methods ($p < 0.001$). No significant differences were observed for knowledge sharing ($p = 0.178$), and platforms for collaboration were marginally substantial ($p = 0.050$). These findings suggest that perceptions of open science practices vary meaningfully by academic stage, with more advanced young people potentially evaluating these methods differently regarding their creative impact.

The post-hoc analysis presented in Table 6 reveals significant differences in how young people at different educational levels perceive the effectiveness of various open science practices in fostering creativity.

Figure 4 presents a heatmap visualizing the Z-scores from post-hoc Dunn's tests, which compare young people's perceived effectiveness of various open science practices across three edu-

Table 5. Kruskal-Wallis test results for perceived effectiveness by education level

Source: Authors' calculation in R Studio.

Method	Variable	χ^2	df	p-value	Significant
Collaborative research	x23	12.69	2	0.00176	Yes
Webinars and online courses	x24	8.03	2	0.01807	Yes
Mentorship and coaching	x25	18.72	2	< 0.001	Yes
Hackathons and innovation	x26	20.00	2	< 0.001	Yes
Peer learning	x27	9.22	2	0.00993	Yes
Knowledge sharing	x28	3.45	2	0.1785	No
Platforms for collaboration	x29	5.98	2	0.0503	(Marginal)
Other open science methods	x30	17.07	2	< 0.001	Yes

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Table 6. Dunn's post-hoc test results for differences in perceived effectiveness of open science practices by education level

Source: Authors' calculation in R Studio.

Open Science Method	Comparison	Z-score	p-value (adj)	Significant?
Collaborative Research	Bachelor – Master	–4.47	0.00002	Yes
	Bachelor – Ph.D.	–0.90	1.00000	No
	Master – Ph.D.	2.61	0.0271	Yes
Webinars & Online Courses	Bachelor – Master	–2.51	0.0358	Yes
	Bachelor – Ph.D.	0.81	1.0000	No
	Master – Ph.D.	2.54	0.0332	Yes
Mentorship & Coaching	Bachelor – Master	–4.19	0.00008	Yes
	Bachelor – Ph.D.	–1.85	0.1943	No
	Master – Ph.D.	1.63	0.3111	No
Hackathons & Competitions	Bachelor – Master	–4.47	0.00002	Yes
	Bachelor – Ph.D.	–0.90	1.00000	No
	Master – Ph.D.	2.61	0.0271	Yes
Peer Learning	Bachelor – Master	–1.35	0.534	No
	Bachelor – Ph.D.	2.42	0.0470	Yes
	Master – Ph.D.	2.99	0.0083	Yes
Knowledge Sharing	Bachelor – Master	–1.20	0.693	No
	Bachelor – Ph.D.	2.63	0.0258	Yes
	Master – Ph.D.	3.06	0.0067	Yes
Platforms for Collaboration	Bachelor – Master	–2.11	0.105	No
	Bachelor – Ph.D.	0.82	1.000	No
	Master – Ph.D.	2.25	0.074	No
Other Methods	Bachelor – Master	–1.54	0.369	No
	Bachelor – Ph.D.	3.48	0.0015	Yes
	Master – Ph.D.	4.00	0.0002	Yes

Note: Significance based on Bonferroni-adjusted p-values ($p < 0.05$).

cational levels: Bachelor's, Master's, and Ph.D. Negative Z-scores (shaded in blue) represent lower perceived effectiveness by the first group in each comparison (e.g., Bachelor compared to Master). In contrast, positive Z-scores (shaded in red) reflect higher perceived effectiveness by the latter group.

Bachelor's students consistently rated several methods less effective than Master's and Ph.D. Students. For example, statistically significant differences were observed between Bachelor's and Master's students in the evaluation of collaborative research ($p = 0.00002$), webinars and online courses ($p = 0.0358$), mentorship and coaching ($p = 0.00008$), and hackathons and competitions ($p = 0.00002$). This trend suggests a developmental progression in recognizing the value of open science practices with academic maturity.

Moreover, Ph.D. Students were significantly more positive than Bachelors in their evaluation of peer learning ($p = 0.047$), knowledge sharing ($p = 0.0258$), and other methods ($p = 0.0015$), indicating that the highest level of study may further enhance appreciation for collaborative and innovative practices. Significant differences were also found between Master's and Ph.D. Students regarding collaborative research, webinars, peer learning, knowledge sharing, and other methods, suggesting a refinement in perceptions even among advanced young people.

Conversely, no statistically significant differences were found for platforms for collaboration, where all group comparisons resulted in adjusted p-values above 0.05. This might indicate a more uniformly perceived value across education levels or a general ambiguity in the effectiveness of this category. These findings support Hypothesis 4, indicating that perceptions of the efficacy of open science practices in enhancing creativity vary significantly depending on the student's level of education, with more advanced young people generally demonstrating a higher valuation of these methods.

Source: Authors' calculation in R Studio.

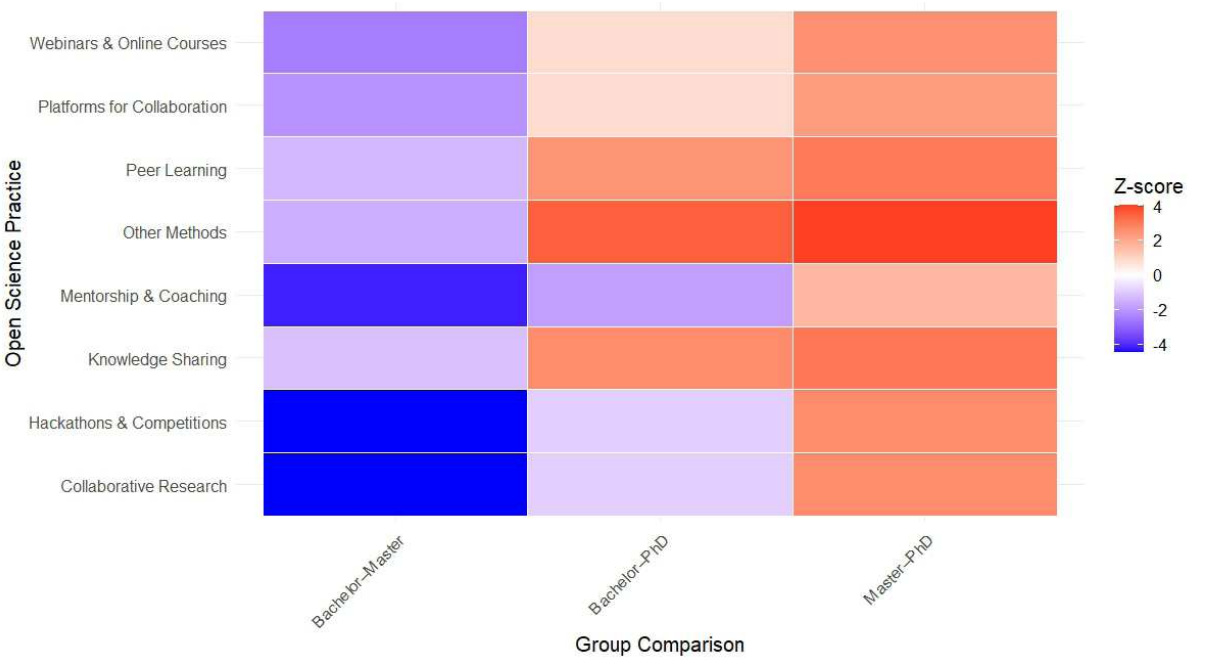

Figure 4. Heatmap of differences in perceived effectiveness of open science practices by education level

The perceived effectiveness of various open science practices differs depending on the student's field.

The Kruskal-Wallis rank sum tests were conducted to examine whether young people's perceived effectiveness of various open science practices differs by their field of study. The results (Table 7) indicate statistically significant differences for two practices: collaborative research, webinars, and online courses.

Table 7. Kruskal-Wallis test results for perceived effectiveness by education field

Source: Authors' calculation in R Studio.

Open Science Practice	χ^2	df	*p*-value	Significant?
Collaborative Research	23.34	9	0.0055	Yes
Webinars & Online Courses	31.69	9	0.0002	Yes
Mentorship & Coaching	8.56	9	0.4789	No
Hackathons & Competitions	9.40	9	0.4013	No
Peer Learning	16.08	9	0.0653	(Marginal)
Knowledge Sharing	12.44	9	0.1899	No
Platforms for Collaboration	13.72	9	0.1327	No
Other Methods	16.43	9	0.0585	(Marginal)

These findings suggest that young people from different academic disciplines evaluate the effectiveness of collaborative research and webinars/online courses in developing creativity differently. For instance, young people in technical or applied fields (e.g., engineering, life sciences) may find webinars more impactful than those in the humanities or social sciences.

For the other practices – mentorship and coaching, hackathons and competitions, peer learning, knowledge sharing, platforms for collaboration, and other methods – no significant differences were found ($p > 0.05$), indicating a relatively consistent perception of effectiveness across fields.

The results partially support Hypothesis 5 by confirming that the field of study can shape how certain open science practices are perceived to foster creativity and motivation. However, this effect is not uniform across all practices. Further post-hoc analyses would help clarify which disciplines differ significantly in their evaluations.

Dunn's post-hoc comparisons for Hypothesis 5 (Table 8) show that differences in perceived effectiveness of open science practices vary across fields. However, only a few comparisons reached statistical significance after Bonferroni adjustment.

For collaborative research (x23), students from Chemistry evaluated its effectiveness significantly differently than those from Engineering, with an

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Table 8. Dunn's post-hoc comparisons (p-values) for differences in perceived effectiveness of open science practices by field of study

Source: Authors' calculation in R Studio.

Comparison	x23	x24	x25	x26	x27	x28	x29	x30
CHE – ECO	0.79351	0.55082	0.78074	0.66076	0.90854	0.49451	0.16574	0.17313
CHE – ENG	0.28960	0.85231	0.99552	0.82824	0.42729	0.94822	0.61765	0.65311
ECO – ENG	0.78293	0.52974	0.24822	0.96240	0.26027	0.48849	0.41826	0.58097
CHE – ENV	0.12657	0.27422	0.30475	0.49356	0.07376	0.23689	0.23749	0.22947
ECO – ENV	0.84458	0.17090	0.74586	0.25194	0.81753	0.12281	0.62279	0.74848
ENG – ENV	0.79784	0.96067	0.43676	0.65299	0.18307	0.64408	0.53850	0.17147
CHE – HUM	0.09764	0.82142	0.03620	0.30738	0.19698	0.38541	0.28477	0.64563
ECO – HUM	0.98188	0.75107	0.30560	0.45913	0.55011	0.03379	0.79747	0.32497
ENG – HUM	0.63412	0.79763	0.13936	0.52357	0.31341	0.35256	0.40962	0.53872
ENV – HUM	0.27847	0.53573	0.80935	0.81736	0.40204	0.30377	0.11046	0.12539
CHE – LIF	0.70850	0.42639	0.55839	0.81091	0.46704	0.15544	0.83160	0.40029
ECO – LIF	0.71503	0.71602	0.34614	0.96491	0.59310	0.60245	0.35041	0.08527
ENG – LIF	0.47252	0.44038	0.23306	0.11259	0.81911	0.18491	0.95132	0.42640
ENV – LIF	0.11161	0.28416	0.29549	0.17409	0.76013	0.32835	0.62044	0.13601
HUM – LIF	0.60614	0.24033	0.42893	0.26006	0.20784	0.64626	0.22011	0.91272
CHE – MAT	0.41424	0.65744	0.40618	0.71402	0.84625	0.56745	0.96901	0.95187
ECO – MAT	0.86536	0.71413	0.64367	0.62627	0.02336	0.25940	0.39772	0.08080
ENG – MAT	0.16939	0.03667	0.40833	0.41487	0.18443	0.67287	0.26352	0.23278
ENV – MAT	0.18014	0.73390	0.58872	0.85458	0.77500	0.82192	0.12677	0.98605
HUM – MAT	0.58903	0.71466	0.18382	0.62833	0.26398	0.48729	0.94383	0.36696
LIF – MAT	0.77925	0.64139	0.49263	0.43823	0.03997	0.59480	0.97151	0.33324
CHE – MED	0.95532	0.75521	0.58299	0.25173	0.70573	0.49682	0.36859	0.35797
ECO – MED	0.64743	0.31896	0.86209	0.02554	0.39801	0.48034	0.15913	0.36343
ENG – MED	0.16134	0.71266	0.64716	0.95993	0.94041	0.11432	0.94460	0.57972
ENV – MED	0.68201	0.18850	0.69990	0.11932	0.78170	0.11464	0.50540	0.06791
HUM – MED	0.02103	0.81275	0.79422	0.64682	0.66639	0.14609	0.05786	0.91100
LIF – MED	0.73062	0.46376	0.98003	0.65537	0.58981	0.17137	0.89492	0.78958
MAT – MED	0.22241	0.09732	0.46487	0.43576	0.27126	0.62723	0.87902	0.62341
CHE – PHY	0.19167	0.73454	0.27497	0.23799	0.59275	0.96659	0.97518	0.09497
ECO – PHY	0.54514	0.02874	0.52256	0.00652	0.67281	0.92757	0.50407	0.51986
ENG – PHY	0.82675	0.06080	0.62766	0.51772	0.15400	0.48991	0.94909	0.10164
ENV – PHY	0.84350	0.73259	0.48323	0.18825	0.49968	0.38795	0.25425	0.82626
HUM – PHY	0.46966	0.85461	0.47626	0.41362	0.52708	0.74911	0.16007	0.41012
LIF – PHY	0.60614	0.95608	0.17412	0.62187	0.51984	0.74593	0.06863	0.33358
MAT – PHY	0.82717	0.55702	0.52392	0.21720	0.03956	0.32561	0.87107	0.95733
MED – PHY	0.24840	0.02378	0.79813	0.84821	0.18775	0.71530	0.10157	0.70439
CHE – SOC	0.68601	0.90128	0.72854	0.22803	0.78464	0.47089	0.87540	0.27036
ECO – SOC	0.68867	0.47345	0.29881	0.16518	0.13898	0.49520	0.13925	0.94225
ENG – SOC	0.07453	0.38677	0.06722	0.48378	0.89242	0.06839	0.85926	0.82236
ENV – SOC	0.16089	0.24094	0.69651	0.07436	0.56818	0.54973	0.82762	0.63539
HUM – SOC	0.00375	0.61046	0.35494	0.44122	0.51987	0.07489	0.58268	0.09199
LIF – SOC	0.70776	0.28825	0.02025	0.82985	0.14881	0.80098	0.95784	0.03926
MAT – SOC	0.80146	0.47213	0.75093	0.68596	0.36797	0.77589	0.84849	0.50608
MED – SOC	0.68285	0.75931	0.73937	0.87536	0.92231	0.25627	0.65853	0.02338
PHY – SOC	0.03365	0.64641	0.75418	0.07459	0.90866	0.03480	0.71982	0.08729

Note: Significance based on Bonferroni-adjusted p-values ($p < 0.05$).

adjusted p-value of 0.0124. A similar difference was observed between students from Physics and Social Sciences (p = 0.0336), suggesting variations in how collaborative methods are valued across scientific traditions.

In the context of webinars and online courses (x24), a statistically significant difference emerged between Engineering and Mathematics students (p = 0.0367), indicating that technological or learning environment preferences may shape how different groups perceive virtual formats.

For mentorship and coaching (x25), Chemistry students differed significantly from those in Humanities (p = 0.0362), suggesting divergent views on personalized support structures in scientific versus more interpretive academic cultures. Regarding hackathons and innovation competitions (x26), students in Economics and Medicine reported differing levels of perceived effectiveness (p = 0.0255), potentially reflecting distinct exposure or relevance of such activities in their curricula.

Peer learning (x27) was generally rated similarly across fields, except that Life Sciences and Mathematics students differed significantly in their ratings (p = 0.0399). For knowledge sharing (x28), most differences were not statistically significant. However, Physics and Social Sciences students approached the significance threshold (p = 0.0348), hinting at variation in how shared knowledge is utilized or valued in those domains.

Perceptions of other open science methods (x30) also varied significantly across disciplines. Notably, students in Mathematics differed from those in Social Sciences (p = 0.0393), and Medical students showed a similar divergence compared to their Social Science counterparts (p = 0.0234). These findings suggest that while a common understanding of open science exists in many areas, meaningful disciplinary differences persist in how specific practices are experienced and valued.

4. DISCUSSION

The findings of this study contribute to a growing body of literature on the role of open science in fostering transformational competences, particularly creativity, among youth in higher education. The study highlights patterns that align with and extend existing research by analyzing how students from different academic levels and disciplines engage with open science practices.

The positive correlation found between the level of education and the frequency of open science usage confirms observations by Kuzior et al. (2024a, 2024b) and Liuta et al. (2021), who emphasize that institutional environments in higher education play a crucial role in shaping students' exposure to innovation-oriented practices. Ph.D. Students' higher evaluations of mentorship, hackathons, and collaborative research as effective creative methods also support findings by Kilgour and Melnyk (2011), who identified advanced academic involvement as a key enabler of dual-path innovation capacity.

Moreover, the moderate correlation between perceived benefits of open access and reported motivation and creativity among students resonates with the work of Artyukhov et al. (2023) and Artyukhov et al. (2024), who underline the transformative impact of open and inclusive knowledge ecosystems. These results also reflect the SPACE-RL model's emphasis on science-business collaboration and innovation transfer.

Disciplinary differences in the perceived effectiveness of specific practices, such as webinars and collaborative tools, particularly among Engineering, Chemistry, and Mathematics students, echo Antoniuk et al. (2017), who showed how sector-specific barriers and opportunities shape the innovative potential of SMEs in high-tech environments. Similarly, Zahidi et al. (2025) demonstrated that proximity and sectoral context affect startup innovation, a finding that parallels how academic disciplines condition open science perception.

This study also aligns with broader trends identified by Memarian and Doleck (2024) and Schinello (2025), highlighting the potential of open systems and ethical digital infrastructures to foster innovation and creativity, particularly when adapted to user needs. The significant differences observed across educational levels and disciplines indicate that a one-size-fits-all approach to fostering

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creativity through open science is insufficient. Instead, as Tessema (2025) and Alemu (2025) suggested, educational interventions must be tailored to different learner groups' dynamic needs and capacities.

Finally, the study adds empirical depth to conceptual arguments by Petrova and Pereira (2024) and Perevozova et al. (2019a), who frame human capital and entrepreneurship as central to technology ecosystems and creative economies. The finding that open science engagement correlates with motivation and idea generation among youth further validates their position, reinforcing the need to integrate open science frameworks into broader strategies for innovative development.

While based on a large and diverse sample of young people from universities across Ukraine, this study is subject to several limitations. First, the cross-sectional design restricts the ability to establish causal relationships between engagement in open science practices and reported creativity or motivation. Second, all data were self-reported, which may introduce social desirability or recall bias, especially concerning perceptions of effectiveness and frequency of use. Additionally, while the survey captured a broad range of academic disciplines and educational levels, the context-specific nature of Ukrainian higher education may limit the generalizability of findings to other countries or educational systems. Although appropriate for the data structure, non-parametric statistical methods may also limit the depth of multivariate analysis that could further explore interactions between variables. Finally, some open science practices may have been interpreted differently by respondents due to varying levels of exposure, potentially affecting the consistency of responses.

CONCLUSION

This study aims to investigate how engagement with open science practices contributes to developing creativity among young people, with particular attention to variations across educational levels and academic disciplines.

A nationwide survey was conducted with 2,250 university students in Ukraine to address this objective. The study collected data on the frequency, perceived value, and effectiveness of open science practices among Bachelor's, Master's, and Ph.D. Students across ten academic disciplines. Given the data's ordinal and non-normally distributed nature, statistical analysis was done using non-parametric methods, including Kruskal-Wallis tests, Dunn's post-hoc comparisons, and Spearman's rank correlations.

The findings revealed several notable patterns. A statistically significant correlation was found between education level and open science usage (Spearman's $\rho = 0.13$, $p < 0.001$), with Ph.D. Students engaging more frequently than Bachelor's or Master's students ($\chi^2 = 44.92$, $p < 0.001$). Students who agreed that open access helps generate ideas reported greater motivation and creativity from open science initiatives ($\rho = 0.37$, $p < 0.001$), with significant group differences ($\chi^2 = 316.71$, $p < 0.001$). The perceived effectiveness of open science methods differed significantly by education level. Ph.D. Students rated mentorship ($p = 0.00008$), hackathons ($p = 0.00002$), and collaborative formats more positively than lower-level peers, indicating a developmental progression in recognizing open science's creative value. Disciplinary differences were significant for collaborative research ($\chi^2 = 23.34$, $p = 0.0055$) and webinars ($\chi^2 = 31.69$, $p = 0.0002$), with Engineering, Life Sciences, and Social Sciences students showing notably different evaluations.

The study highlights that academic progression and field of study significantly influence how young people engage with and perceive the creative potential of open science practices.

Based on these results, universities and educational policymakers should consider integrating open science education into early academic stages to build familiarity and skill. Targeted support should be

offered according to academic level, with more advanced tools and collaborative experiences provided to Master's and Ph.D. Students. Furthermore, institutions should develop discipline-sensitive strategies to promote open science, ensuring that initiatives resonate with different academic domains' specific needs and contexts. Promoting access to open publications and interactive formats like hackathons, mentorship, and peer learning can enhance young people's motivation and creativity, ultimately fostering a more innovative and participatory academic culture.

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APPENDIX A

QUESTIONNAIRE

What is your current level of study?

- Bachelor's
- Master's
- Doctoral/Ph.D.

What is your field of study?

- HUM: Humanities & Arts
- SOC: Social Sciences (including Law)
- ECO: Economic Sciences
- LIF: Life Sciences
- MED: Medicine (incl. Veterinary Medicine)
- MAT: Mathematics
- CHE: Chemistry
- PHY: Physics
- ENG: Information Sciences and Engineering
- ENV: Environment and Geosciences

How often do you use open science practices (e.g., open data, open-source code, open educational resources) while completing learning tasks?

- Very often
- Often
- From time to time
- Rarely
- Never

Please indicate your opinion on the following statement: "Using open science practices helps me generate new ideas and approaches to solving learning tasks."

- Always
- Often
- Sometimes
- Rarely
- Never
- I do not know

Do you agree that using open access to scientific publications helps you generate new ideas and approaches to solving learning tasks?

- Agree
- Rather agree
- Neutral
- Rather disagree
- Disagree
- I do not know

http://dx.doi.org/10.21511/kpm.09(2).2025.12

Please indicate your opinion on the following statement: "Participation in open science initiatives (e.g., crowdsourcing projects) increases your motivation for learning and creativity."

- Agree
- Rather agree
- Neutral
- Rather disagree
- Disagree
- I do not know

How do you assess the effectiveness of open science methods for developing your creativity?

Table A1. Open science methods assessment checkbox

Open science method	Effective	Rather effective	Neutral	Rather ineffective	Ineffective	I do not know
Collaborative research						
Webinars and online courses						
Mentoring and coaching						
Hackathons and innovation competitions						
Collaborative learning						
Knowledge sharing						
Collaboration platforms						
Other						