



KAPITEL 3 / CHAPTER 3³
**STEM EDUCATION IN NON-STEM FIELDS: ANALYSIS OF
EXPERIENCES OF TEACHERS AT PEDAGOGICAL UNIVERSITIES IN
UKRAINE**

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Introduction

Nowadays, the implementation of STEM education requires significant transformations within the traditional educational system. This process aligns with current labor market demands, where interdisciplinary cognitive, research, technological, and communication competencies – as well as skills in information processing, data interpretation, and analysis – are increasingly valued [1]. Engineering and algorithmic thinking, digital literacy, creativity, and teamwork are also added to this list, as they enable modern professionals to make innovative decisions, integrate new technologies effectively into their work, and address relevant socio-economic challenges [2].

Thus, in addition to subject-specific knowledge, teachers of various disciplines must foster these skills in children and youth while ensuring the effective training of a new generation of innovators by promoting STEM careers among students in educational institutions [3].

This situation necessitates a rethinking of approaches to STEM education, particularly through its expansion via integration with other educational domains. One promising direction is the combination of STEM with the humanities, which offers new opportunities for developing well-rounded individuals and unlocking the potential of interdisciplinary learning.

According to some researchers, integrating STEM with the humanities helps students better understand the social and ethical contexts of scientific innovation. The focus is not only on the development of STEM competencies but also on the cultural relevance of technological change. Through such integration, STEM becomes more human-centered and applicable to the real world. It cultivates future leaders who are

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not only capable of developing technologies but also of using them responsibly in society [4], while also deepening their understanding of the links between science and the surrounding world [5].

Others emphasize the potential of such integration to raise students' awareness of artificial intelligence, which is no longer optional but essential for quality preparation in today's digital society [6]. A well-established practice is the inclusion of an artistic component into STEM disciplines to foster creative thinking and to develop students into flexible, innovative professionals capable of navigating uncertainty and global challenges [7].

While most existing studies focus on integrating the humanities into STEM fields, the reverse approach – embedding STEM elements into humanities education – also holds significant potential. We view this integration as an effective tool for promoting scientific and technical creativity among students who may have consciously chosen to avoid STEM careers. However, the success of this approach largely depends on the preparation and motivation of educators who implement interdisciplinary practices in school settings. It is therefore logical that the competence level of these teachers, as well as their readiness to adopt the interdisciplinary approach inherent to STEM, directly determines the effectiveness of such integration [8].

Despite growing public interest in integrating STEM into the educational process, several unresolved challenges still hinder its effective implementation. For example, Ukraine's officially approved Concept for the Development of Natural and Mathematical (STEM) Education [9] outlines a governmental action plan aimed at fostering key student competencies in science, technology, engineering, and mathematics. This is to be achieved through curriculum modernization, program updates, active use of digital technologies, and the implementation of motivational systems for school learners. However, this policy document simultaneously introduces a limitation by designating the integration of STEM as a priority solely for teachers of physics, mathematics, and primary education. Teachers of other disciplines are, for unclear reasons, excluded from this process. As a result, teacher education institutions often overlook this issue, treating it as optional.



Some scholarly works highlight limited STEM literacy even among schoolteachers from STEM-related fields. For example, over half of the surveyed Indonesian physics teachers reported that they had never implemented STEM lessons in practice, despite possessing theoretical knowledge of the approach. Some were even unable to identify relevant school topics where STEM could be applied [10]. Similar results were found among Turkish teachers, who lacked experience integrating the engineering component – a key element of STEM education [11]. Teachers of non-STEM disciplines face even greater difficulties, often perceiving STEM as the domain of science educators and lacking the confidence to implement it [12]. This is despite the fact that interdisciplinary teaching – even outside the STEM context – is prioritized across all advanced education systems.

Another major barrier identified by researchers is the lack of resources [13]. Many schools lack the necessary equipment to meet modern STEM teaching requirements, making effective instruction nearly impossible. Additionally, the absence of clear implementation guidelines, low teacher readiness for innovation due to professional overload, and lack of consistent support structures all further complicate STEM integration [14]. Difficulties adapting to new pedagogical approaches, a lack of experience in STEM integration, and limited awareness of relevant standards and assessment tools further exacerbate the issue [15]. A systematic review of scholarly literature revealed significant disparities in teachers' readiness for STEM implementation depending on country, educational level, and subject specialization. The least prepared were early childhood and primary educators, primarily due to the insufficient inclusion of engineering and technology components in their training [16].

In summary, teachers face a number of challenges that hinder the implementation of the STEM approach in educational institutions [9-16]. We believe that some of these issues can be addressed early during pre-service teacher education at higher education institutions (HEIs). This is especially important for disciplines not traditionally associated with STEM. In the long term, addressing this will be critical for the successful adoption of STEM approaches by non-STEM teachers across all levels of education, from preschool to higher education. Faculty members in HEIs, who define



and deliver teacher training programs, have been identified as key change agents in this process [17]. However, they may also face resistance from colleagues or lack institutional support when attempting to introduce innovative STEM practices [18].

This issue is particularly relevant for Ukraine, where STEM has been identified not only as a priority for educational development, but also as a strategic necessity in addressing contemporary challenges, including those caused by war – such as environmental, economic, security, social, and humanitarian issues [19].

Under these circumstances, it becomes especially important to analyze the current state of affairs specifically, the extent to which non-STEM instructors integrate STEM approaches into their teaching practices within higher education institutions.

Results

The push for broader implementation of STEM methodology across all disciplines reflects a response to the dynamic challenges of the modern world. In an era of rapid technological advancement and increasing reliance on swift decision-making based on interdisciplinary data, traditional boundaries between academic fields are becoming increasingly blurred. This shift necessitates a corresponding change in educational strategies, where an interdisciplinary approach is not merely an option but a prerequisite for effective learning.

The analysis of responses from teachers regarding the relevance of STEM education for students in non-STEM specialties at Berdyansk State Pedagogical University allowed for essential conclusions to be formulated (Figure 1).

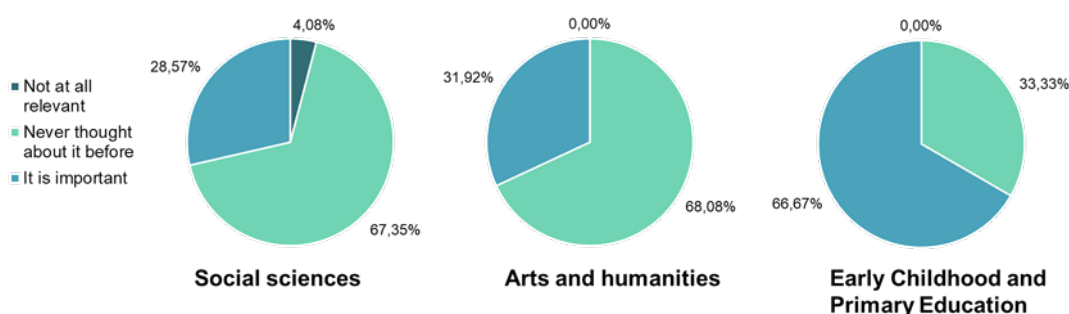


Figure 1 - Responses of respondents to the question, “How relevant do you consider STEM education to be for students in your specialty?”

A source: Created by the authors.



Among instructors in the “Social Sciences” category, a relatively small proportion (4.08%) considered STEM to be “not relevant at all.” It is encouraging that active resistance to STEM integration is minimal. However, there remain some non-STEM faculty who consciously do not support interdisciplinary approaches. Notably, the majority of responses from this group (67.35%) indicated a complete lack of experience in implementing STEM elements within social science disciplines. Many admitted they had never previously considered such a possibility. Nonetheless, 28.57% recognized the potential value of STEM education, demonstrating openness to integrating its elements into social science curricula.

In the “Arts and Humanities” category, none of the respondents indicated that STEM education was “not relevant at all” for Ukrainian society. However, the majority (68.08%) stated that they had “never previously considered the relevance of STEM education for humanities disciplines.” This indicates both a lack of experience in integrating STEM and the persistence of a belief among non-STEM faculty that their disciplines are inherently disconnected from science and technical creativity – domains traditionally associated with STEM. Only 31.92% acknowledged the importance of STEM education, emphasizing the interdisciplinary benefits it could offer the humanities.

In contrast, instructors in the “Early Childhood and Primary Education” category displayed a notably different pattern of perception. None of the respondents viewed STEM as “not relevant at all.” A much smaller proportion (33.33%) reported that they had never thought about the advantages of STEM education or its integration into the training of future preschool and primary school teachers, compared to the previous category. In fact, 66.67% fully recognized its significance. This could be explained by the fact that legal and policy documents regulating early childhood and primary education in Ukraine already mandate stimulating curiosity, supporting learning motivation, encouraging independent research, constructing simple devices, and engaging children in investigative activities. As a result, instructors in this category are more experienced in STEM-related practices than their counterparts.

These findings illustrate differing levels of perception of STEM education among



non-STEM faculty members. While many responses still reflect a perceived separation of STEM from the arts, humanities, and social sciences, there is a clear recognition of its relevance. We view this as an indicator of the future potential for development in this area provided that targeted awareness-raising efforts are implemented and a roadmap for introducing STEM elements into non-STEM disciplines is developed.

To analyze the extent to which non-STEM faculty at HEIs may already be implementing STEM-based practices, the questionnaire included the following item: “Do you offer STEM-oriented tasks to your students during their professional training?” The responses were categorized into six groups: “Never,” “Very rarely,” “Rarely,” “Often,” “Very often,” and “Always” (see Fig. 2).

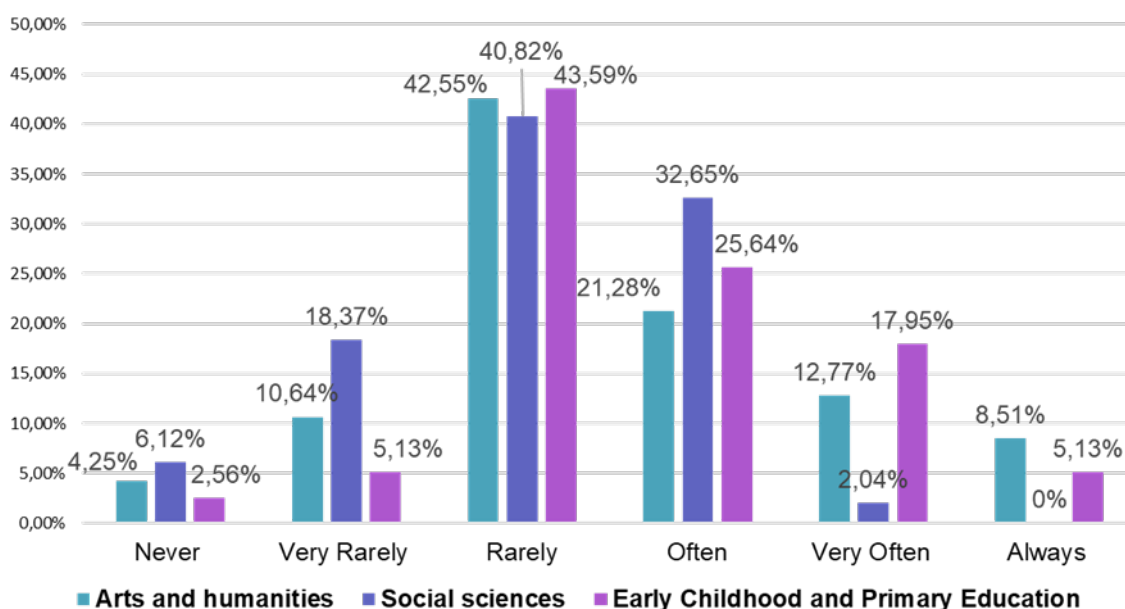


Figure 2 - Respondents’ responses to the question: “Do you offer STEM-oriented tasks to students in the process of their professional training?”

A source: Created by the authors.

As illustrated in Figure 2, within the “Arts and Humanities” category, a small percentage (4.25%) of respondents indicated that they “never” offered STEM-oriented tasks to students, reflecting a certain degree of resistance or lack of awareness regarding the implementation of STEM in non-STEM disciplines. A larger portion (10.64%) responded “very rarely,” while the largest share (42.55%) chose “rarely.”



These responses suggest that despite some efforts to integrate STEM, instructors offer such tasks irregularly, indicating that they may not yet perceive them as a valuable instructional method. Importantly, 21.28% of respondents in this category reported that they “often” offer STEM-oriented tasks to future non-STEM teachers, and another 21.28% said they do so “very often” or “always.” This implies that approximately one-quarter of instructors in this group clearly recognize the relevance of integrating STEM into their teaching as a means of developing essential competencies.

Instructors in the “Social Sciences” category demonstrated a somewhat different pattern. A higher proportion (6.12%) stated they had “never” assigned STEM-oriented tasks to students. A considerable share selected “very rarely” (18.37%) or “rarely” (40.82%). Only 32.65% indicated that they “often” offer such tasks, while merely 2.04% selected “very often.” This distribution points to limited activity in implementing STEM approaches within social science disciplines.

The responses from instructors in the “Early Childhood and Primary Education” category revealed a significantly higher level of engagement in integrating STEM-oriented tasks into professional training. These results are consistent with previous questionnaire responses regarding the perceived relevance of STEM education for students in these fields. Only 2.56% of respondents in this group indicated they had “never” assigned STEM tasks, while 10.26% selected “very rarely” or “rarely.” A quarter (25.64%) reported that they “often” used STEM-oriented tasks in their teaching, and a considerable proportion (23.08%) stated they used them “very often” or “always.” These results reflect a positive attitude and genuine interest among non-STEM faculty in this category toward incorporating STEM into their pedagogical practice – an evident advantage for preparing future educators who will, in the long term, support STEM implementation across all levels of education, from early childhood to higher education (K – 20).

Overall, the findings indicate substantial variation in the frequency of STEM integration across non-STEM disciplines. Instructors in the “Arts and Humanities” and “Social Sciences” categories, while expressing interest in STEM, have comparatively less practical experience than those in the “Early Childhood and Primary Education”



group. Nonetheless, the presence of even modest positive outcomes suggests a promising foundation for further development and dissemination of STEM education in fields traditionally considered outside its scope.

The instructors’ responses to the question, “How often do you offer STEM-oriented tasks to students during their teaching practicum, coursework, thesis writing, or independent work at the higher education institution (HEI)?” provided comprehensive insight into the current level of STEM integration in various forms of academic work across disciplines at Berdiansk State Pedagogical University (Figure 3).

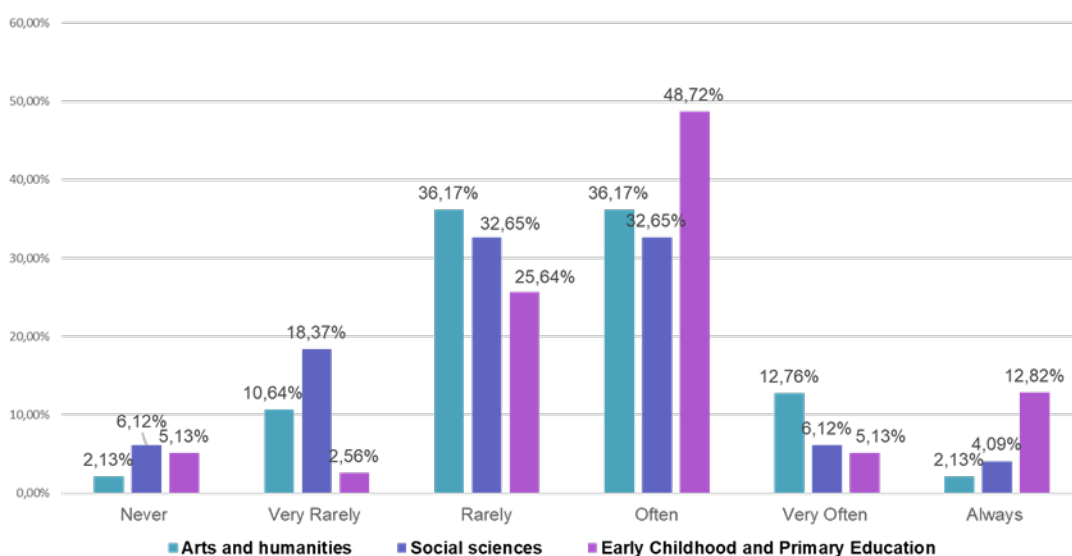


Figure 3 - Respondents: “How often do you offer HEI students STEM-oriented tasks during their internships, course writing, master's theses, and independent work?”

A source: Created by the authors.

In the "Arts and Humanities" category, a small portion (2.13%) of respondents indicated that they "never" assigned STEM-oriented tasks during students’ teaching practicum, coursework, thesis writing, or independent projects. A further 10.64% responded “very rarely,” while equal shares of instructors (36.17% each) selected “rarely” and “often.” This reflects a certain balance – many instructors occasionally integrate STEM, while an equal number do so more frequently. However, given that such types of academic work inherently involve research components, it is concerning



that only 12.76% of instructors "very often" and a mere 2.13% "always" offer STEM-oriented assignments.

Responses from the "Social Sciences" category revealed that a significant number of instructors "rarely" (32.65%), "very rarely" (18.37%), or "never" (6.12%) include STEM-oriented tasks in activities such as coursework, thesis writing, or independent projects across disciplines like economics, political science, sociology, and special education. On the other hand, some instructors demonstrated an interest in integrating STEM approaches: 32.65% responded "often," 6.12% "very often," and 4.09% "always." This distribution highlights varying levels of experience with STEM integration among faculty and aligns with previous questionnaire findings on the perceived relevance of STEM for students (see Fig. 1), where 67.35% admitted they had never considered applying STEM approaches within non-STEM disciplines.

In contrast, instructors in the "Early Childhood and Primary Education" category showed more consistent and active engagement in using STEM-oriented tasks. Only 5.13% reported "never" using STEM tasks, and 2.56% selected "very rarely." One-quarter (25.64%) indicated "rarely," while nearly half (48.72%) stated "often." Additionally, 5.13% chose "very often," and 12.82% reported "always" integrating STEM-oriented tasks into student field placements, research papers, and other academic activities. This again highlights strong support among instructors in this group for implementing STEM principles at the foundational levels of education.

Despite the positive trend in recognizing the relevance of STEM among non-STEM faculty, responses to the question, "How is the topic of STEM education reflected in the content of the subjects you teach?" revealed inconsistent – and in some cases, inaccurate – understandings of STEM-oriented approaches. Some respondents equated STEM with general digital or soft skill activities (e.g., making presentations, creating video lessons, practicing critical thinking or teamwork), while others explicitly stated that STEM was irrelevant to their subjects. At the same time, several responses demonstrated genuine experience with interdisciplinary integration, including the use of 3D modeling, statistical methods, specialized digital platforms, meaningful project-based learning, or topics related to scientific and technological innovation.



Additionally, we examined whether there was a correlation between instructors' recognition of the relevance of STEM and the frequency with which they incorporated STEM tasks in teaching (see Table 1). Given that both variables were ordinal, Spearman's rank-order correlation was applied.

The analysis revealed a moderate positive correlation between perceived relevance of STEM (ranked from "not relevant" to "very relevant") and frequency of using STEM tasks (ranging from "never" to "always"), $r_s = 0.42$, $p < 0.01$. In other words, the higher the level of awareness and acknowledgment of STEM's importance among faculty, the more frequently they employ related methods in their teaching practice.

We also investigated whether instructors' academic rank (assistant, senior lecturer, associate professor, professor) correlated with their frequency of assigning STEM-oriented tasks. The Spearman correlation showed a weak but statistically significant relationship, $r_s = 0.28$, $p = 0.03$. This may suggest that instructors of higher academic rank integrate STEM elements more frequently, possibly due to greater methodological expertise or involvement in project-based teaching. However, some early-career instructors also demonstrated notable examples of STEM integration in the humanities.

Overall, the findings confirm the existence of statistically significant relationships between key study variables, which should be taken into account when designing professional development programs for instructors of non-STEM disciplines.

Table 1 - Spearman Correlation Analysis Between Key Study Variables

Variable Pair	Spearman's Correlation Coefficient (r_s)	Significance (p)	Interpretation of Relationship
Perceived relevance of the STEM approach ↔ Frequency of using STEM-oriented tasks	0.42	< 0.01	Moderate positive correlation
Instructor's category ↔ Frequency of implementing STEM-oriented tasks	0.28	0.03	Weak positive correlation

A source: Created by the authors.



In summary, the findings reveal significant disparities in the integration of STEM into non-STEM specializations. A low frequency of offering STEM-oriented tasks was observed among instructors categorized under "Arts and Humanities" and "Social Sciences." In contrast, instructors in the "Early Childhood and Primary Education" category demonstrated greater awareness and a broader experience of STEM integration compared to their peers. These results highlight the importance of recognizing the unique characteristics of non-STEM disciplines and the distinct needs of various instructor categories when developing effective strategies to support STEM implementation in higher education institutions (HEIs).

However, the integration of STEM components into the humanities remains insufficiently comprehensive, limiting opportunities for the holistic development of students' scientific culture. This barrier narrows the potential for cross-disciplinary collaboration and hinders the formation of a cohesive STEM-oriented educational ecosystem, especially given that, in the modern world, every subject can serve as a starting point for cultivating students' scientific and technical thinking. Language, history, and arts teachers, for instance, can become active promoters of STEM ideas through interdisciplinary projects or other creative learning formats.

The belief that STEM education should extend beyond natural sciences and permeate all disciplines is highly relevant today. This notion aligns with the findings of other researchers who emphasize the need to enhance university instructors' qualifications in STEM education [20]. The rationale is clear: university educators are responsible for preparing qualified teachers who can meet the current demands of society. Such integration equips them with essential methodological knowledge and diverse skills to apply scientific principles in various teaching contexts [21]. Furthermore, the spread of STEM into non-STEM specializations may contribute to the development of broader and more innovative pedagogical experiences.

Therefore, our focus has been directed toward instructors of non-STEM specializations in higher education institutions (HEIs). The analysis confirms a widely held academic view that the level of awareness and openness to STEM integration among educators of different disciplines is uneven.



In particular, instructors in the "Arts and Humanities" category demonstrated noticeable ambivalence regarding STEM integration. While many respondents had never previously considered the potential of STEM education within their fields, the majority expressed a positive attitude toward its prospects, with a few even successfully implementing STEM-oriented tasks in their classes albeit in somewhat limited ways (e.g., developing a digital presentation was sometimes viewed as a STEM project). Respondents in the "Social Sciences" category showed the greatest passivity in integrating STEM into their educational processes.

The reluctance or hesitation to embrace the interdisciplinary approach and the limited initiative to embed STEM components into non-STEM specializations may be attributed to deeply rooted perceptions among humanities educators that their fields are fundamentally separate from the natural sciences and technical creativity typically associated with STEM. There is also a lack of specialized resources for these disciplines that could help address the issue. Consequently, this results in a lack of STEM competence and a corresponding lack of confidence in applying the interdisciplinary approach in practice.

However, the presence of a portion of non-STEM educators, especially those in "Early Childhood and Primary Education" who regularly assign STEM-oriented tasks to their students already signals the promise of further development in this direction. It is noteworthy that our findings contradict other studies that have shown primary and preschool teachers to be less informed and experienced in STEM compared to their colleagues in secondary education [22].

One possible explanation for the greater STEM awareness among the "Early Childhood and Primary Education" instructors in our study is the nature of their professional training, which often involves the integration of subjects for children. Another factor may be the specifics of Ukraine's national education policy. Unlike some foreign countries where primary school teachers often lack access to STEM-oriented resources, Ukraine has had a Concept for the Development of Natural and Mathematical Education (STEM education) in place since 2020. This document emphasizes the importance of preparing educators in primary education (as well as



physics, mathematics, and computer science) for STEM implementation. This may have influenced the survey results and partly explains why this category demonstrates greater experience with STEM tasks and a better understanding of interdisciplinary teaching approaches. Thus, the identified differences are likely shaped not only by individual initiative but also by the influence of national strategies for teacher education reform in Ukraine.

Nevertheless, such variation in instructors' perspectives reveals a lack of unified approaches, misunderstandings regarding the principles of STEM education, and a need for additional methodological support for instructors seeking to implement STEM in non-STEM contexts.

Integrating STEM elements into the humanities can be particularly beneficial for developing students' critical thinking and analytical skills. Acquiring modern digital tools and data-processing technologies can also enhance students' employability by equipping them with valuable market-relevant competencies. Familiarizing future teachers with the principles of STEM education can lay a strong foundation for interdisciplinary instruction and problem-solving skills in their own students.

Our study, therefore, sheds light on the specific landscape of STEM integration into non-STEM disciplines, characterized by varying degrees of awareness and implementation among humanities instructors. "Early Childhood and Primary Education" faculty appear to be the most active in applying STEM practices, while those in the "Arts and Humanities" and "Social Sciences" show less initiative. This disparity underscores the need for a coordinated and intentional effort to promote STEM education and embed its approaches and methods into all pedagogical disciplines.

These efforts should include:

1) Initiatives for upskilling educators across various specializations in integrating STEM into their subjects. For example, through hands-on workshops, dedicated training programs, or collaborative projects designed to bridge the gap between STEM and non-STEM domains.

2) A review of existing curricula for students in different disciplines to



systematically include STEM components that complement and enrich subject-specific content.

3) Encouragement of collaborative projects and research between STEM and non-STEM educators to enhance professional development and foster a culture of interdisciplinary respect.

4) Development and distribution of essential resources (both material and instructional) to support the integration of STEM across diverse disciplines.

It is important to note that such initiatives should aim not merely at STEM-content inclusion, but at cultivating a genuine "STEM mindset" among university instructors and students one that values science, inquiry, experimentation, and interdisciplinary collaboration regardless of their specialization. In light of this, the recommendation for comprehensive STEM integration into non-STEM university programs becomes a compelling call to action. It paves the way for breaking down stereotypes and embracing the dynamic, interconnected nature of knowledge in the 21st century. As higher education is always at the forefront of reform, university instructors play a pivotal role in shaping the future workforce one that is not only technically proficient but also innovative and holistic in its approach to problem-solving and knowledge creation.

Summary and conclusions.

The empirical study conducted at Berdyansk State Pedagogical University provides a quantitative assessment of university instructors' understanding of the importance of integrating STEM into non-STEM specializations. The survey results reveal a clear differentiation in STEM implementation among instructors from different disciplines. In the fields of Arts and Humanities, 68.08% of instructors had never previously considered the relevance of STEM to their disciplines, and only 31.92% acknowledged its importance. Even more detached from this issue were instructors in the Social Sciences. They demonstrated very limited awareness: only 28.57% recognized the value of STEM elements for their disciplines, while 6.12% considered it entirely irrelevant. Notably, instructors in the "Early Childhood and



Primary Education" category demonstrated the highest level of awareness and experience with STEM integration – 66.67% of responses, twice as much as in the other categories.

It is important to note that our study is limited to a single university, which may not fully reflect broader trends across different regions or types of educational institutions in Ukraine. Moreover, the online survey format – necessitated by the temporary relocation of the university due to war and occupation – may have influenced the objectivity of participants' responses.

Despite these limitations, the study offers valuable insights and promising ideas for the future of STEM education in Ukraine. It highlights the need to improve the professional qualifications of instructors in non-STEM fields and to reform curricula through the integration of STEM elements into all specialties where such content is currently lacking.

Further research should aim to include a broader range of institutions, both within Ukraine and internationally, to determine more precise and generalizable trends in STEM integration into non-STEM disciplines. In parallel, examining specific barriers and catalysts for STEM education across different fields will provide deeper insight for the more effective implementation of interdisciplinary approaches in educational practice.

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