Integrating History and Software Engineering: A STEM-Based Approach to Teaching

Iryna Zavadska
Department of Professional and Special Education
Educational and Rehabilitation Institution of Higher Education "Kamianets-Podislkyi State Institute"
Kamianets-Podilskyi, Ukraine
zavadskascience@ukr.net

Anatolii Skrypnyk
Department of Inclusive Education, Rehabilitation and Humanities
Educational and Rehabilitation Institution of Higher Education "Kamianets-Podislkyi State Institute"
Kamianets-Podilskyi, Ukraine
skranat@i.ua

Oksana Palyliulko
Faculty of Socio-Psychological Activities, Rehabilitation and Professional Education
Educational and Rehabilitation Institution of Higher Education "Kamianets-Podislkyi State Institute"
Kamianets-Podilskyi, Ukraine
Palelulko1980@ukr.net

Oleksandr Shevchuk
Department of Digital, Educational and Socio-Economic Technologies
Educational and Rehabilitation Institution of Higher Education "Kamianets-Podislkyi State Institute"
Kamianets-Podilskyi, Ukraine
evruka@i.ua

Artur Mykhailyk
Department of Professional and Special Education
Educational and Rehabilitation Institution of Higher Education "Kamianets-Podislkyi State Institute"
Kamianets-Podilskyi, Ukraine
mykhailyk_artur@ukr.net

Abstract- **The interdisciplinary approach is an effective method in technical education, particularly for integrating humanitarian disciplines with specialised subjects. However, history, philosophy, Ukrainian, and foreign languages often receive minimal teaching hours, leading to insufficient mastery. To address this, we explored the integration of history and culture with technical disciplines, specifically "Modern Programming Paradigms" and "Methods and Systems of Artificial Intelligence," to enhance learning for future software engineers. A STEM project was implemented to explore Ukrainian statehood through engineering solutions and modern technologies. First-year Computer Science students engaged with interactive digital tools, including low-code web application frameworks (Glitch, WordPress), historical data visualisation (Flourish), timeline and mapping tools (TimelineJS, StoryMapJS), and interactive presentations (Canva, Google Slides). The project's effectiveness was assessed using a rubric-based evaluation with three key criteria: content, technology, and collaboration. The analysis showed no statistically significant differences between teams (p > 0.05), indicating consistent engagement. The highest score was in "Collaboration" (3.47), demonstrating effective teamwork. The "Technology" criterion (3.23) reflected satisfactory proficiency in software tools, while "Content" scored the lowest (2.73), highlighting challenges in integrating historical narratives with programming. Correlation analysis showed a weak relationship between criteria, meaning technical skills did not necessarily translate into high-quality content or teamwork. A SWOT analysis based on an anonymous student survey provided direct feedback for improving future STEM projects. Key advantages included deeper assimilation of historical facts, practical application of programming skills, and teamwork experience. However, students noted limited time for mastering content and a lack of necessary equipment as challenges. These findings highlight the need to strengthen the historical component and improve programming integration with humanities for a more comprehensive learning experience.**

Keywords- Computer Sciences, History of statehood and culture, Software Engineers, STEM Projects, Programming

I. INTRODUCTION

Until recently, Ukraine has been experiencing a trend towards reducing the number of subjects in the humanities cycle in non-humanities institutions. Some scholars have even suggested eliminating the history course from curricula, arguing that this is due to the similarity of topics and the sequence of presentation of the material, as well as new requirements for a modern engineer. However, such approaches do not consider the specifics of teaching history in higher education institutions, which should be carried out problem-based [1] with the

obligatory adaptation of the course of history and culture of the country to the specialization of students.

The development of science and technology will determine humanity's general progress [2]. At the same time, a critical factor for the economies of developed countries is the contradiction between the constantly growing shortage of specialists in high-tech industries and the decline in student's interest in natural and mathematical sciences [3].

To become a competitive IT engineer, an extraordinary training trajectory should be developed for students in technical specialties. One of the components of such training should be the integration of unique disciplines of the IT industry with subjects of artistic direction, in particular, courses on art history, design theory, graphic arts, etc. Such integration will contribute to developing social and personal competencies [4].

An interdisciplinary approach creates "bridges" between different branches of knowledge, contributing to the enrichment of methodological tools and the formation of new scientific knowledge [5], [6]. In particular, integrating humanitarian and technical disciplines allows future engineers to acquire a wide range of knowledge and skills. The profession of a software engineer, according to the four-level classification of occupations, combines the types of "man-technician", "man-human", and "man-sign systems". This requires a specialist with technical competencies, a broad outlook, and knowledge of the humanities (philosophy, psychology, management).

Literature review.

Scientists emphasize that forming complex competencies in a modern software engineer is impossible without including humanitarian disciplines in the educational process [7]. Among the effective methods for developing the professional culture of software students, it is worth noting that professional discussions contribute to the formation of critical thinking and communication skills [8].

Researchers also emphasize the feasibility of integrating a foreign language with specialized disciplines during the training of future programmers [7], [9].

A literature review indicates limited experimental studies devoted to integrating history and STEM disciplines, particularly in the interaction between teachers of different subjects [10]. History is often perceived as a discipline focused on the past, while engineering is focused on the future, which creates specific barriers to integration. However, studies demonstrate the potential benefits of such a combination for developing critical thinking and a deeper understanding of the subjects.

For example, Park and Song [11] examined the possibilities of studying the history of science using ancient Chinese mathematical texts. Another study showed the successful reconstruction of Charles Page's electromagnetic motor as part of an interdisciplinary project for K-12 students [12].

These examples demonstrate that integrating history with STEM subjects deepens subject knowledge and stimulates students to think creatively and find unconventional solutions.

The paper aims to investigate the effectiveness of the integration of such disciplines as history and programming through projects with students majoring in Computer Sciences. The research focuses on examining central software engineers' competencies in the multidisciplinary context, assessing the impact of projects in acquiring knowledge in Ukrainian state-building, and determining strong and weak options for STEM projects through SWOT analysis. The ultimate goal of the study is to identify ways to optimise STEM projects in non-humanitarian higher education institutions.

II. MATERIALS AND METHODS

A group of historians and a lecturer from the Department of Digital, Educational and Socio-Economic Technologies created a project called "Interactive Chronology of Ukrainian Statehood". The STEM project aimed to teach future IT specialists to analyze historical events, think critically and visualize them in the form of technological solutions; develop programming skills using tools and technologies to create an application interface; visualize historical data in the form of graphs and charts, as well as work together on the project.

The experiment was conducted at the Kamianets-Podilskyi State Institute with 1st-year bachelor's students majoring in Computer Science. Students from two groups (n=30) were divided into five teams. Classes were held weekly during the 1st semester of the 2024 academic year as part of the Statehood and Culture Studio.

The article used quantitative and qualitative methods of analysis. ANOVA analysis of variance was used to determine statistically significant differences between teams according to the rubrics. Correlation analysis was used to identify the presence or absence of a relationship between the evaluation criteria. Average scores were also calculated to diagnose the success of students' projects. Anonymous student questionnaires and SWOT analysis were used as qualitative methods of analysis.

III. RESULTS AND DISCUSSION

Students were to research the following stages of Ukrainian statehood: Kyiv Rus, Hetmanate, UNR, and independent Ukraine, focusing on historical events, figures, and key dates. Next, work continued to create a web application. Given the initial level of digital competencies, students used simple technologies. Flourish was used to visualize historical events, and TimelineJS and StoryMapJS were used to depict a particular period visually. Students were invited to use Canva or Google Slides to create interactive presentations.

The project defence took place in the form of an application demonstration. The STEM project was evaluated in three categories: Content, Technology, and Collaboration on a scale of 1 to 5. History teachers evaluated the first category, the second by a programming teacher, and the third by all teachers.

The following statistical data processing methods were used to analyze the results of the STEM project: calculation of average scores for each rubric for each team, as well as analysis of variance (ANOVA) to determine statistically significant differences between teams. The average scores for each team are given in (1).

TABLE 1 DISTRIBUTION OF POINTS FOR EACH CATEGORY

Team	Content	Technology	Collaboration
Team 1	4.00	3.83	3.33
Team 2	2.17	3.67	3.17
Team 3	2.67	3.50	3.00
Team 4	2.50	2.33	4.00
Team 5	2.33	2.83	3.83
Total	2.73	3.23	3.47

The overall average scores for the three criteria for all teams showed that the lowest average score was obtained in the "Content" category (2.73). This indicates a superficial and insufficiently deep study of the material on the history of statehood and culture. In contrast, the average scores in the "Technology" category (3.23) demonstrate sufficient technical skills for implementing STEM projects. The highest average score (3.47) was recorded in the "Collaboration" category, which indicates effective teamwork, successful communication, and joint decision-making during the implementation of the STEM project.

To assess the differences in task performance between teams, analysis of variance (ANOVA) was used according to the specified criteria (Fig.1).
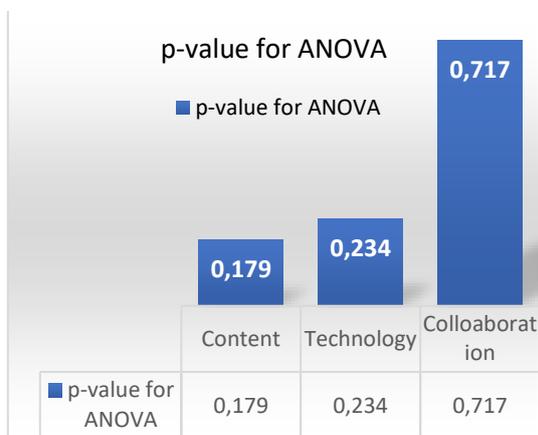

Fig. 1.   Graphical presentation of the results of analysis of variance (ANOVA) according to the specified criteria

In the "Content" category, the p-value is 0.179. Since the *p-value* $\geq$ 0.05, there are no statistically significant differences between the achievements of the teams.

The analysis of variance for the "Technology" category also did not reveal significant differences (*p-value* = 0.234), which indicates the same level of mastery of modern technologies among students.

The highest *p-value* (0.717) was recorded in the "Collaboration" category, which confirms the uniformity of teamwork and effective communication in all teams.

The absence of statistically significant differences between teams indicates an even distribution of knowledge among students and the effectiveness of the teaching methodology.

To conduct a SWOT analysis of the STEM project, an anonymous survey of students was organized, which included the following questions:

• What aspects of the project did they like the most (with the ability to select multiple options)?

• How did the project affect the understanding of historical topics?

• What difficulties did the respondents encounter?

The survey results formed the basis of the SWOT analysis, the results of which are shown in Table 2.

TABLE 2 THE SURVEY RESULTS FORMED THE BASIS OF THE SWOT ANALYSIS

STRENGTHS	WEAKNESSES
Developing teamwork and communication skills. Improving programming skills and working with modern technologies. Contributes to a deeper understanding of Ukrainian state-building and culture.	Lack of time for in-depth study of the topic can lead to a superficial perception of the material. Lack of access to necessary equipment may hinder effective project implementation. Uneven workload among team members.
OPPORTUNITIES	**THREATS**
Using successful elements of the project to develop new courses and programs. Possibility of involving experts in history and programming to conduct master classes and seminars	Frequent technology updates can necessitate rapid professional development for students and faculty. Internal conflicts within a group can negatively affect the learning atmosphere.

The combination of humanitarian and technical knowledge within the STEM project primarily contributed to developing teamwork and effective communication, key skills for future IT engineers. While working on the project, students could apply their programming skills in practice to create a web application, which allowed them to combine theoretical knowledge with real technological solutions.

The SWOT analysis showed that the successful elements of the project can be integrated into new courses and curricula. At the same time, the initial goal was to significantly deepen students' knowledge of the history of statehood and culture of Ukraine. However, the results indicate that the best indicators were achieved in developing teamwork and using modern technologies.

Among the identified weaknesses of the project is the limited time for completing tasks, which led to a superficial study of historical material. Given this, it would be advisable to plan similar STEM projects in the second semester when students already have basic knowledge of history. An alternative option could be to focus on one historical period, for example, the Hetmanate or the Ukrainian People's Republic, for independent study. This will help develop search skills and foster research interest.

IV. CONCLUSIONS

The STEM project, created based on the interdisciplinary interaction of the courses "History of Statehood and Culture" and "Modern Programming Paradigms and Methods of Artificial Intelligence", demonstrated success in developing teamwork, effective communication, and collective decision-making - key skills for future IT specialists. Students confidently applied their technical competencies to create a web application, confirming achieving goals in the programming field.

However, the content component of the project turned out to be less developed, which indicates the need to adjust the methodology for a deeper assimilation of historical material.

To improve the content of the project, it is necessary to:

1. *Review of the project structure*

- Increase the time needed to process historical material before starting work on the technical part.
- Transfer the implementation of the project to the second semester of the first year so that students have basic knowledge of history.
- Distribute historical periods between teams for a deeper analysis of individual stages: Team 1 — Kyiv Rus, Team 2 — Hetmanate, Team 3 — UNR, Team 4 — Independent Ukraine.

2. *Involvement of specialists and interactive methods:*

- Organize consultations, seminars and guest lectures with the participation of expert historians.
- Use the opportunities of university history clubs to conduct quests, debates and thematic studies.
- Involve students in analyzing sources and creating interactive visualizations (for example, chronological maps or timelines).

3. *Adjustment of the assessment system:*

- Increase the weight of the assessment for the "Content" category in the overall result to stimulate a deeper study of the material.

- Introduce intermediate control - mandatory stages of assessment before moving on to the technical part.
- Use self-assessment and mutual assessment elements to determine each participant's contribution to studying historical topics.

The STEM project demonstrated high effectiveness in developing team and technical skills; however, it is necessary to improve the methodology for mastering the content part to balance the humanitarian and technical components. The proposed adjustments will improve the results in the "Content" category and increase the overall quality of the project, creating conditions for integrated learning and the development of critical thinking.

REFERENCES

[1] S. O. Kostylieva (Ed.), Current Issues of Teaching the History of Ukraine and the History of Ukrainian Culture in Higher Education: Proceedings of the Interuniversity Scientific and Methodological Seminar (Kyiv, December 18, 2009). Kyiv: IVC "Publishing House "Polytechnika", 2010, 89 p. [Online]. Available: https://history.kpi.ua/wp-content/uploads/2020/01/2014-12-05.pdf [Accessed: Oct. 05, 2024].

[2] O. Y. Stryzhak, I. A. Slipukhina, N. I. Polikhun, and I. S. Chernetckiy, "STEM Education: Basic Definitions," Information Technologies and Learning Tools, vol. 62, no. 6, 2017, pp. 16 https://doi.org/ 10.33407/itlt.v62i6.1753.

[3] N. I. Polikhun, I. A. Slipukhina, and I. S. Chernecjkyj, "STEM Pedagogical Technology as a Means to Reform the Ukrainian Educational System," Education and Development of Gifted Personality, no. 3(58), 2017, pp. 5-9 https://doi.org/10.33407/itlt.v62i6.1753.

[4] O. Savluk, "Computer Graphics: Capabilities of Information Technologies in the Higher Education System," Youth and Market, no. 7(205), 2022 https://doi.org/10.24919/2308-4634.2022.267310

[5] V. O. Ognevyiuk, S. O. Sysoieva, O. O. Drach, K. O. Lynyov, Educational Science: Professional Training: Teaching and Methodical Manual, V. O. Ognevyiuk, Ed., Kyiv: VP "Edelweiss", 2014.

[6] A. M. Kolot, "The Interdisciplinary Approach as a Prerequisite for the Development of Economic Science and Education," Bulletin of Taras Shevchenko National University of Kyiv. Series: Economics, no. 158, 2014. [Online]. Available: http://nbuv.gov.ua/UJRN/VKNU_Ekon_2014_5_5. [Accessed: Nov. 09, 2024].

[7] V. S. Kruhlik and V. V. Osadchyi, "Interdisciplinary Approach in the Professional Training of Future Programmers," Pedagogical Education: Theory and Practice. Psychology. Pedagogy., no. 27, 2017. [Online]. Available http://nbuv.gov.ua/UJRN/itvo_2012_12_12 [Accessed: Nov. 19, 2024].

[8] V. O. Lishchyna, "Peculiarities of Training Future Programmers in Higher Educational Institutions and the Development of Their Professional Culture," Scientific Notes of Rivne State University for the Humanities, vol. 7, no. 50, 2013, pp. 90–92. [Online]. Available: http://nbuv.gov.ua/UJRN/Kitonv_2017_27_24 [Accessed: Nov. 29, 2024].

[9] O. Chaikovska, V. Spivachuk, I. Humeniuk, and V. Holinei, "Integrated Approach to Teaching ESP at Engineering University," Engineering for rural development. Jelgava, 2021, pp.1200-1206 https://doi.org/10.22616/ERDev.2021.20.TF263

[10] W. Park and H. Cho, "The Interaction of History and STEM Learning Goals in Teacher-Developed Curriculum Materials: Opportunities and Challenges for STEAM Education," Asia Pacific Education Review, vol. 23, no. 3, 2022, pp. 457–474. https://doi.org/10.1007/s12564-022-09741-0

[11] W. Park and J. Song, "Looking Back at 'Our Science' and 'Our History': An Exploration of Korean Preservice Science Teachers' Encounters with East Asian History of Science," Cultural Studies of Science Education, 2021. [Online]. Available: https://doi.org/10.1007/s11422-021-10060-w [Accessed: Feb. 01, 2025].

[12] D. A. Slykhuis, L. Martin-Hansen, C. D. Thomas, and S. Barbatom, "Teaching STEM through Historical Reconstructions: The Future Lies in the Past," Contemporary Issues in Technology and Teacher Education, vol. 15, no. 3, 2015. [Online]. Available: https://citejournal.org/volume-15/issue-3-15/editorial/teaching-stem-through-historical-reconstructions-the-future-lies-in-the-past [Accessed: Sep. 25, 2024].