

Continuous development of STEAM skills based on collaborative interaction between stakeholders

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Abstract. STEAM (Science, Technology, Engineering, the Arts, and Mathematics) education is becoming increasingly important in today's society, which demands interdisciplinary skills, creativity and adaptability to emerging technologies. The literature emphasises the role of innovative pedagogies (project-based learning, design thinking, gamification, etc.) and university-industry collaboration in aligning education to real market needs. In this paper, based on the results of the Erasmus+ Skills4Future project, we analyse the continuous development of STEAM competences through collaborative interaction between students, teachers, institutions and industrial partners. The mixed methodology involves comparing the pilot phase (academic year 2023-2024) with the adjusted phase (2024-2025) of integrated STEAM courses: quantitative (student satisfaction questionnaires) and qualitative (open feedback) data were collected. The main results indicate high levels of satisfaction in both phases and improvements in key indicators after adjustments. Quantitative data show the significant impact of the quality of didactic interaction and practical components on overall student satisfaction. The qualitative analysis emphasises the appreciation of applied activities and team collaboration, confirming the importance of anchoring learning in real contexts. The contribution of the study lies in highlighting a model of curriculum co-creation and systematic feedback that enables the continuous alignment of STEAM study programmes with market demands and sustainability priorities.

Keywords: STEAM skills, university-industry collaboration, innovative curriculum, applied learning, gamification, curriculum design.

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Introduction

The importance of developing STEAM (Science, Technology, Engineering, the Arts, and Mathematics) competences has increased significantly in today's society, which demands graduates with interdisciplinary skills, creativity and adaptability to emerging technologies. At the same time, current trends in European and global education policies encourage close collaboration between universities and industry to ensure the relevance of vocational training and curricular innovation. Such collaborations facilitate the alignment of academic skills with the real needs of the labor market and society, contributing to sustainable development. In this policy context, Skills4Future operationalizes these priorities by embedding STEAM competences and industry-relevant tasks directly into course design and assessment.

The Erasmus+ Skills4Future project (no. 101081787) is in line with this, aiming at *developing and improving STEAM competences of students and teachers* for curricular innovation and sustainable development of higher education institutions and the local business environment (in line with the project objectives). This project involves diverse stakeholders - universities, students, professors, industry partners - working together to modernize university courses by integrating STEAM skills. The process involves piloting the new content, collecting feedback from the beneficiaries (students) and subsequently adjusting the curriculum in a cycle of continuous improvement. The importance of student feedback in this endeavor is crucial: soliciting learners' opinions has proven to be one of the most effective measures for improving teaching and curriculum. In the modern paradigm of curriculum design, which emphasizes process and

student-centered learning, student input through feedback becomes crucial to design a curriculum that is relevant, reliable and effective for their needs. Thus, feedback is not only an assessment tool but also a *driver for continuous curriculum development*, motivating teachers to adapt their methods and content to the learners' perspective.

In this context, this paper aims to analyze how students' STEAM competences can be continuously developed through a *collaborative interaction between stakeholders* - students, teachers, academic institutions and industrial partners. It investigates the results of feedback from students participating in the innovative STEAM courses developed in the *Skills4Future* project at the *State University of Moldova*, comparing the *pilot phase* (initial implementation, academic year 2023-2024) with the *adjustment phase* (revision and improved implementation, academic year 2024-2025). The analysis covers both the *quantitative* component - students' level of satisfaction on key dimensions (course organization, quality of theoretical materials, quality of practical applications, achievement of STEAM learning objectives in terms of knowledge and skills) - and the *qualitative* component, through thematic coding of students' observations on aspects such as collaboration, difficulties encountered and their motivation. Based on these data, we will highlight the impact of stakeholder involvement in the educational process and draw conclusions and implications for future STEAM curriculum improvement practices.

Theoretical framework

The literature review emphasizes the complex and interdisciplinary nature of STEAM education and the need for innovative pedagogies to cultivate the competences required by contemporary society. The STEAM paradigm expands the STEM approach by including the arts and the creative dimension, aiming to produce graduates who are able to solve complex problems, innovate and collaborate effectively in diverse teams. According to Zhan et al. (2023) [1], the goals of STEAM education converge towards developing collaboration, innovation and adaptability in students, preparing them for the challenges of the technological age. The integration of new technologies (e.g. digital tools, e-learning platforms, virtual labs) and modern pedagogical methodologies (project-based learning, design thinking, gamification, etc.) has proven beneficial in increasing STEAM learning engagement and effectiveness.

A central element highlighted in the literature is the *collaboration between stakeholders* in the educational process. According to the *triple helix* [2] and *quadruple helix* approaches [3], innovation and skills development require synergistic interaction of academia with industry, government and society. *University-industry collaboration* in particular is perceived as a catalyst for innovation, facilitating the exchange of knowledge and technology. Ankrah and Al-Tabbaa (2015) note that such partnerships have intensified in response to the pressures of the global competitive environment and the need for universities to update their educational offerings, demonstrating the potential to increase organisations' knowledge stock and generate innovative solutions [4]. In the educational context, the involvement of industrial stakeholders in curriculum development (through consultation, co-creation of content, provision of real case studies, mentoring, etc.) increases the relevance of training, stimulates students' practical orientation and develops their *employability* skills. Students are more engaged and motivated when they recognise the *real-world applicability* of what they learn - recent research indicates that anchoring STEM/STEAM learning in real-world contexts increases its attractiveness and impact on students.

The literature also highlights the need to adopt innovative and *student-centered teaching methods* in promoting STEAM skills. *Project-based learning, problem-based methods, gamification, and interdisciplinary learning* are some examples of approaches that have proven effective. Parody et al. (2022) showed, for example, that the use of gamification in a university course (Classcraft platform) led to increased academic performance and the development of the '4Cs' - critical thinking, communication, collaboration, creativity - in students compared to traditional instruction [5]. This supports the idea that playful and interactive teaching methods can increase learners' motivation and engagement, while improving their social-emotional competences. Similarly, Montés et al. (2022) implemented an integrated STEAM approach (the EXPLORIA project) in an engineering programme [6], structuring learning around practical challenges and steps; the effectiveness of the new methodology was validated by the positive feedback from students, who appreciated its relevance and applicability. Such studies confirm that updating the curriculum with innovative pedagogical methods and interdisciplinary content has a significant impact on student satisfaction and achievement of learning outcomes.

Finally, yet equally significant, the theoretical framework of this paper is supported by concepts of *formative assessment and continuous curriculum improvement*. According to Scriven (1967, as cited in Wiliam, 2014), feedback obtained during the educational process (formative assessment) is essential for adjusting teaching and clarifying objectives, as it allows educators to identify learning gaps in real time and modify instructional strategies to enhance student understanding and achievement [7]. In the curriculum-as-process paradigm, *the curriculum is built iteratively*, including possible adjustments based on student feedback and performance. Thus, involving students in course evaluation (through questionnaires, focus groups, etc.) becomes a vital practice: on the one hand, it provides teachers with information about the effectiveness of the methods and materials used; on the other hand, it makes students co-participants in the improvement of the educational act. Informal and practical evidence suggests that this process leads to a better alignment of courses with the real needs of learners and to an increase in the quality of learning. In this paper we

follow this approach, examining how student feedback from the pilot phase was used to optimize courses in the fine-tuning phase, highlighting the benefits of ongoing collaboration between students and teachers in instructional design.

Methodology

Our study followed a mixed quantitative and qualitative research design structured around two main phases: the initial piloting of the updated courses with STEAM elements (academic year 2023-2024) and their adjustment based on the collected feedback, followed by the second round of implementation (academic year 2024-2025). The methodological objective was to assess the impact of the curricular enhancements on student satisfaction and learning outcomes, as well as to identify the main themes from students' qualitative feedback on their learning experience in these innovative courses.

The following research methods and procedures were addressed:

1. *Data collection and descriptive quantitative analysis.* For each course piloted in the project (5 disciplines in the field of business administration, taught at the State University of Moldova, 3rd year undergraduate), *feedback questionnaires* were collected from students at the end of the semester. The questionnaires included *Likert-scale* items on different dimensions of the course: organizational aspects (structure and organization of the subject, clarity of the teacher's explanations, degree of difficulty, workload, usefulness of the applied topics, effectiveness of the digital tools used, etc.), newly added theoretical materials and resources (quality of the course materials, relevance of the theoretical STEAM content introduced), added practical exercises and applications (usefulness and relevance of the practical STEAM activities), as well as the degree of achievement of the expected learning outcomes related to STEAM competences - separated by specific *knowledge* (K) and *skills* (S). Quantitative data (percentages of students who rated each aspect as *Excellent*, *Good*, *Satisfactory* or *Unsatisfactory / Inadequate*) were analysed descriptively (frequency distributions, percentage means) and comparatively between the pilot and adjustment phases. For aggregation at dimension level, the total proportion of respondents giving positive ratings (*Good* or *Excellent*) on each dimension assessed was considered. The results were presented graphically to highlight the differences between the two phases (pilot vs adjustment).

2. *Econometric analysis (inferential quantitative modeling).* A multiple linear regression model was estimated to identify *the determinants of overall student satisfaction*. In the absence of a direct item of overall satisfaction, a composite index was constructed (or overall satisfaction was considered as an integrated student perception) and modeled according to the scores on the main dimensions: (i) quality of organizational aspects, (ii) quality of theoretical materials, (iii) quality of practical applications, (iv) perception of achievement of learning outcomes - knowledge, (v) perception of achievement of learning outcomes - skills. The model was estimated separately for each phase, but also combined, using the least squares (OLS) method. The regression coefficients obtained and their statistical significance(*p*) were examined to determine to what extent the improvements made in the adjustment phase altered the relationship between the factors considered and student satisfaction. For example, we expected the quality of the didactic interaction and the applied-learning component to have a significant positive effect on satisfaction, in line with the literature emphasizing the role of attitude and playful/applied aspects in satisfaction with STEM education. The validity of the model was checked using indicators such as R^2 and tests of overall significance (*F*).

3. *Qualitative analysis (thematic coding).* The feedback questionnaires included open-ended questions, asking students to mention *positive aspects of the course*, *difficulties encountered* and *suggestions for improvement*. Students' qualitative responses were analyzed using the thematic coding technique, identifying recurring themes. The coding was carried out manually by the research team, following the following steps: (i) reading all responses and noting the main ideas, (ii) generating initial codes (labels) for similar concepts, (iii) grouping the codes into broader *thematic categories*, (iv) reviewing the themes and clearly defining each one. To increase reliability, two researchers independently coded a sample of responses, then compared the coding schemes and reconciled any differences. A priori themes of interest included: collaboration and teamwork (comments related to working in a group, interacting with teachers or external partners), perceived difficulties (comments on workload, complexity of content, technical or other obstacles) and motivation and interest (references to how interesting, relevant or motivating the course was and what stimulated the student's interest). This complementary qualitative analysis contextualized the quantitative results and provided a nuanced picture of the students' experience of the piloted STEAM courses.

Bias and validity considerations. We acknowledge potential biases arising from *self-selection* (students who chose to respond may be more motivated or satisfied) and *social desirability* (a tendency to provide favorable ratings toward instructors or courses). To mitigate these risks, we triangulated *quantitative* (item distributions and regression analysis) and *qualitative* evidence (thematic coding by two researchers with reconciliation), and reported both *positive* and *critical* comments. Nevertheless, these biases may inflate satisfaction indicators and should be considered when interpreting the results.

The research methodology described above has been applied to both the 2023-2024 *pilot phase* and the 2024-2025 *adjustment phase* data, allowing a direct comparison of the evolution of student satisfaction and the effectiveness of improvement interventions. In the following, we present the results obtained, followed by a discussion of their significance and practical implications.

Results and discussions

The results of the quantitative feedback, as key dimension, show a high level of student satisfaction for all the dimensions assessed, since the pilot phase, with trends of maintenance or slight improvement in the adjustment phase (Figure 1). Regarding *the organization of the courses*, over 90% of students were satisfied (rating “Good” or “Excellent”) both in the pilot (about 90%) and after adjustments (about 92%). In the pilot phase, the majority of students appreciated the structure of the courses, the quality of the explanations provided by the teachers and the organization of the activities, with only about 10% giving a “Satisfactory” rating, thus indicating room for improvement. Overall, *the organizational aspects* (such as clarity of teaching, organization and interaction during the course) were a strength of the courses, reflecting the pedagogical competence of the teachers and their efforts to create a pleasant learning environment. This is supported by the students' responses: for example, the *explanations given by the teachers* were rated as “excellent” or “good” by 100% of the students in the Business Communication course (adjustment phase), and *the teachers' ability to raise interest in the subject* received positive ratings of 94.6%. These data underline the crucial role of teachers and interactive methods in overall learner satisfaction.

In terms of theoretical materials and learning resources, satisfaction levels were also predominantly positive, with about 85% of students satisfied in the pilot phase and a slight increase to 88-90% in the adjustment phase (Figure 1). The introduction of new theoretical content focusing on STEAM concepts (e.g. elements of sustainability, critical thinking, innovation) was generally well received. In the pilot, between 76% and 90% of students rated the new material as good or excellent, depending on the course. In the adjustment phase, the appreciation of theoretical materials remained high overall, but with notable variations between sub-topics: students rated the lessons highly favorably with a practical-applicative or soft skills character, but were more critical of the highly technical chapters. This pattern suggests that complex technical topics tend to be more difficult to assimilate and require improvements in presentation or didactic support. Correspondingly, we noted that no students marked this content as “Excellent” in cases such as the one mentioned, highlighting *a potential gap in clarity or accessibility* for such specialized topics. In conclusion, the updated theoretical resources were on the whole well received, especially when linked to practical applications and student interests (e.g. communication, negotiation - areas with immediate applicability, rated about 91% positive). However, where the content was very technical or abstract, feedback indicated a need for additional support or more intuitive explanations. It is therefore recommended to revise and enrich the materials for more difficult topics (through visuals, additional case studies or simplification of language) to ensure a consistent level of satisfaction across all theoretical components.

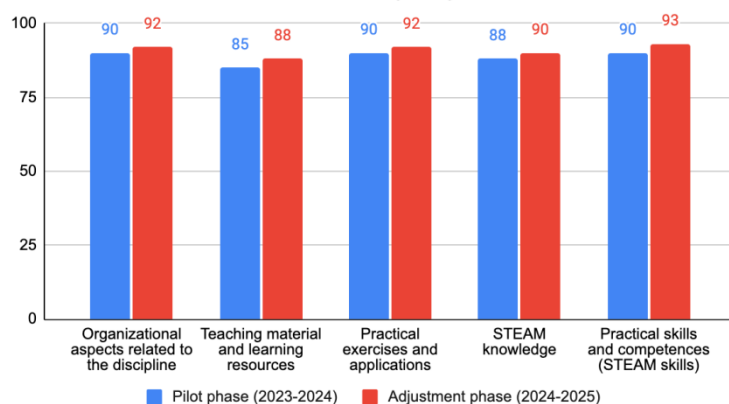


Figure 1: Percentage of students rating the main aspects of STEAM courses as “Good” or “Excellent”, comparing the pilot phase (2023-2024) and the adjustment phase (2024-2025)

Source: Author’s own contribution based on Skills4Future internal reports (2024, 2025) on student feedback

The *practical exercises and STEAM applications* introduced also generated an enthusiastic response from students. Since the pilot phase, *more than 90%* of students have been satisfied with the new practical components, with many rating them “Excellent”. On average about 90-95% of the students positively appreciated the proposed practical activities (Figure 1), confirming their enthusiasm for applied learning. With the adjustment phase, the practical applications were refined and maintained their attractiveness, with the overall satisfaction rate increasing slightly (about 92-93% satisfied, Figure 1). In some cases, the results were impressive: in the adjusted Business Communication course, *100% of students* were satisfied with the practical application on negotiation, with 44.6% even rating it “Excellent”. This result mirrors the trend also observed for the corresponding theoretical material, suggesting that the topics of a technological nature required a more inspired practical translation. Overall, however, the feedback confirms that *practical learning* was a strong element of the upgraded STEAM curriculum: students particularly appreciated activities based on real-life scenarios, interpersonal skills and concrete applications, believing that they enhanced their

understanding and actively involved them in the learning process. This is consonant with the literature, which shows that real-life and collaborative problem solving enhances student engagement and satisfaction in applied science.

A central objective of the introduction of STEAM components in these courses was to improve student learning outcomes, both in terms of conceptual *knowledge*, practical *skills* and attitudes. The questionnaires assessed students' perceptions of the extent to which they had achieved specific learning objectives (aligned to the STEAM competences targeted by the project). The results are very encouraging: the overwhelming majority of students consider that they have achieved these objectives to a good extent in both phases of the project

For STEAM knowledge (e.g. concepts of sustainability, innovation, systems thinking), over about 85-90% of students indicated on average that the learning outcomes were “*met*” or “*fully met*” (Figure 1). The knowledge competences targeted by the project (in the area of sustainability, innovation, systemic approach, collaboration, etc.) were acquired at a high level by the students, confirming that the modernization of the curriculum and the teaching methods used largely achieved the intended purpose. Less robust areas (such as thinking in terms of complex systems) constitute action points for future improvements - for example, the inclusion of *interactive models* or *simulations* to make these concepts more understandable.

In terms of practical skills and competences (STEAM skills), student feedback is also positive, indicating a *high degree of skill formation*. On average, 90% of the students reported that they achieved the targeted skills (Figure 1). STEAM practical skills - ranging from teamwork, communication and problem solving to systems thinking and sustainable action - were successfully cultivated through the curricular interventions in the project. Comparing the pilot with the adjustment shows *modest but noticeable progress* on some indicators, confirming that revising the courses after feedback has had a positive impact. Most importantly, none of the targeted competences remained at a low level of achievement: even the most problematic ones (e.g. systems thinking, mentioned above) were at least partially achieved by most students, with the remaining competences being achieved to a high or very high extent. This indicates a successful alignment between educational objectives and teaching-learning activities, which is essential in a competence-oriented curriculum.

Econometric model of student satisfaction. To explore the relationship between the quantitative factors analyzed (organization, materials, applications, K and S outcomes) and overall student satisfaction, we estimated a multiple linear regression model. The results (standardized β coefficients) are presented in Table 1 below. The pooled model (across the entire sample of respondents, $N \approx 200$) was significant ($R^2 \approx 0.74$, $p < 0.001$), indicating that about 74% of the variance in overall (self-reported) satisfaction can be explained by the included factors.

Table 1: Multiple linear regression model estimation results for overall student satisfaction (standardized coefficients)

Predictor	Coefficient (β)
Organizational aspects	0.28***
Theoretical materials	0.12**
Practical applications	0.26***
Learning (knowledge)	0.14***
Learning (skills)	0.12**

Source: Authors' own research based on aggregated student feedback data.

Notes: *** $p < 0.001$; ** $p < 0.01$.

Interpretation of the coefficients confirms initial expectations and provides some additional insights. It is observed that the most important factors influencing overall satisfaction are the organizational aspects of the course ($\beta \sim 0.28$, $p < 0.001$) and the quality of practical applications ($\beta \sim 0.26$, $p < 0.001$). In other words, *the more favorably students perceived the organization and conduct of the course (coherent structure, clear teaching, effective didactic interaction) and the more satisfied they were with the practical part (applied exercises, projects, relevant case studies)*, the higher their overall satisfaction was. This result is also supported by the descriptive data: for example, in courses with very high overall satisfaction, students emphasized precisely the excellence of teaching and the strong practicality of learning. The literature also confirms that *students' positive attitude towards teaching methodology* (often reflecting organizational aspects, such as teacher involvement and clarity of explanations) is a major determinant of their satisfaction. Similarly, the “*game*” factor and *practical applications* are strongly correlated with satisfaction with and acceptance of STEM education, which corresponds with the high coefficient found for *Practical applications*.

Factors related to achievement of learning outcomes have significant positive coefficients, but of smaller magnitude ($\beta \sim 0.14$ for Knowledge, $\beta \sim 0.12$ for Skills, both $p < 0.01$). This suggests that students who feel *they have actually learned and developed skills* tend to be more satisfied overall, but the impact of perception on learning, while real, is more moderate compared to factors related to course delivery. One possible reason for this is that students may

be very satisfied with the learning experience (due to interesting teaching and applications), even if they do not feel that they have *fully achieved* all the knowledge objectives - their satisfaction stems from the process and not exclusively from the cognitive outcome. However, the significant contribution of the *learning* variables indicates that students positively evaluate courses from which they feel they came away with new knowledge and improved skills, which was to be expected.

Interestingly, the quality of theoretical materials emerges as the factor with the lowest weight in the model ($\beta \sim 0.12$, $p < 0.01$). Although significant, its impact is lower than the other factors. This may reflect the fact that students attach relatively lower importance to textbooks and written materials relative to course experience and practical applications when formulating their overall satisfaction. It is possible that as long as the theoretical materials are of *adequate* quality (without necessarily being exceptional), overall satisfaction remains high, especially if the rest of the elements (teaching, practice) are very good. For example, we have seen in the qualitative feedback that students tolerated possible shortcomings in the theoretical content if the lecturer managed to keep the course interesting and if the applications helped them to compensate and better understand the theory. At the same time, where the theoretical material had shortcomings (such as the highly technical chapters), students nevertheless continued to rate the course overall due to other positive aspects - for example, in the Business Communication course discussed above, despite the moderate rating of the Information Systems chapter, overall satisfaction remained high, on the back of very good ratings of the teaching, exercises and other chapters. Thus, the model's result confirms the intuition that, in order to increase student satisfaction, the emphasis should be on *teaching methods and active involvement* and on the *connection between theory and practice*, without neglecting the quality of the information content.

Overall, the econometric model highlights an important message: qualitative, interactive and applied educational experience is the key to student satisfaction. This empirically supports the orientation addressed by the Skills4Future project - that of modernizing teaching through collaboration and practice. It also confirms the trends identified in the literature: student satisfaction in STEAM is strongly influenced by *subjective and motivational factors* (such as positive attitudes generated by an enjoyable and fun learning environment), which in turn are determined by how teachers and curriculum engage students' interest. In our case, student engagement through hands-on projects, interactive discussions and collaborative work was the decisive factor in satisfaction - a result that aligns with the findings of other studies, for example the beneficial impact of gamification on motivation and collaboration mentioned above.

Qualitative analysis - insights from student feedback. The students' narrative responses to the open-ended questions allow us to understand *why* they evaluated the courses in the way presented above and what aspects they consider important. By coding these responses, we have identified a few main themes that recur in students' comments:

- The topic of collaboration and collaborative learning environments was particularly valued by students, noting the opportunities to work together with peers and to communicate openly in the courses. Many respondents mentioned that working in teams on projects and group discussions helped them better understand the material and prepared them for real work situations. These observations validate the importance of collaborative interaction between all actors (student-student and student-teacher) in the learning process, as emphasized by the project objectives and the literature.

- A frequent theme in the qualitative responses was related to the difficulty of some content and workload. A number of students reported that certain topics (particularly those of a more technical or abstract nature, such as *information systems analysis*, *applied mathematical concepts*, etc.) were difficult to complete. Students suggested some solutions to these difficulties, such as *slowing down the pace of teaching* on the complicated parts, providing *additional resources for study* (video tutorials, additional practical examples) or *focusing on the essentials* of the theory before moving on to the details. However, the focus on difficulties emphasizes the need to balance the curriculum: intellectual challenge needs to be calibrated with appropriate support so that students do not become demotivated. Implicitly, this feedback guided the adjustments made by teachers in 2024-2025 (e.g., assignments were distributed more evenly, recapitulatives were introduced, information density was reduced in some courses), which translated into a decrease in the perception of overload.

- Motivation and interest in learning. Many qualitative responses emphasized that the way the courses were run made students *more interested and motivated* to learn. They appreciated the practical and real-life nature of many of the activities, noting that when they worked on real case studies, hands-on projects or discussed industry examples, *they realized the direct relevance* of the knowledge, which increased their interest. The students also noted the enthusiasm and passion of the teachers as a motivational factor: some wrote that *the teacher conveyed positive energy, showed passion for the subject*, which in turn made them curious and engaged. A novel element that emerged from the feedback was that some students felt motivated by the very idea of participating in an innovative international project (Erasmus+): it was mentioned by a few that they knew that this course was part of a larger modernization project and that their opinions mattered for change.

- Involvement of external factors (industry) and connection to the real world. Although it was not an explicit theme in many responses, we noted that where the courses included contributions from *industry specialists* (through guest speakers or real case studies provided by companies), students mentioned them appreciatively. Students even suggested extending these collaborations: one feedback suggested organizing visits to local companies or involving

students in small consultancy projects for companies as part of the course to learn applied learning. These suggestions show students' desire to have an even closer link with industrial reality, confirming that opening the curriculum to external stakeholders is perceived as beneficial.

Industry collaboration perspective. Although this study did not collect direct survey data from industry partners, the student feedback consistently highlighted the value of guest sessions, real company case studies, and practitioner examples integrated into the courses. These elements increased perceived relevance, motivation, and confidence in applying knowledge to real problems. From the standpoint of external stakeholders, the model piloted here provides a low-barrier entry point for collaboration—partners can contribute cases, short talks, mentoring, or project briefs without large time commitments. In future cycles, we plan to introduce structured industry inputs (e.g., mini-consultancy projects, joint rubrics for evaluating deliverables, and optional micro-internships) and to systematically collect partner feedback on student performance and curricular fit. This addition will enable a more balanced assessment of collaboration outcomes across students, faculty, and industry.

Overall, the qualitative analysis confirms and complements the conclusions drawn from the quantitative data. Students most value the *collaborative, interactive, hands-on and real-world relevant aspects* of these courses. They recognize modernization efforts and are enthusiastic about being part of an innovative learning process. They also do not hesitate to point out difficulties and areas where the experience can be optimized, thus providing *valuable feedback for continuous improvement*.

Conclusions and implications

The present study investigated how students' STEAM competences can be developed and strengthened in an iterative process based on close collaboration between students, teachers, university and industry partners. Analysis of the feedback data collected within the Erasmus+ Skills4Future project highlights some key findings:

1. *The innovative curricular interventions have led to high levels of student satisfaction*, both in the pilot phase and (especially) after subsequent adjustments. Students were overwhelmingly satisfied with the structure and delivery of the courses, the study materials and the practical activities offered. The most appreciated elements were the quality of the didactic interaction (clear teaching, involvement, constructive feedback from teachers) and the application component (relevant practical exercises, team projects, real case studies), confirming the importance of these factors as determinants of satisfaction. A comparison between the pilot and the adjustment shows that the satisfaction indicators were maintained or improved, suggesting that the changes made on the basis of feedback (e.g. improving the course structure, adapting the amount of information, diversifying resources) had the intended effect. Thus, *curriculum designers and university instructors should prioritize student-centered strategies that integrate clear instructional delivery, interactive teaching methods, and practical, real-world applications* — such as team projects and case studies — as these significantly enhance student satisfaction and perceived course quality.

2. *The targeted knowledge competences and practical skills were largely achieved*, demonstrating the effectiveness of integrating STEAM elements into the curriculum. Students report that they have mastered key concepts of sustainability, innovation, critical and systemic thinking, as well as practical skills of collaboration, problem solving and knowledge application. Remarkably, *over 90% of students consider objectives such as the ability to work in teams for sustainable change or the importance of collaboration in organizations - essential skills for future professionals - to be achieved*. Also, the *sustainability education* component seems firmly anchored: students have understood and internalized principles such as the need for interdisciplinary approaches to complex problems (e.g. climate change), the importance of preventive action and resource efficiency. The only objectives where difficulties were evident were the very complex ones (e.g. deep understanding of the dynamics of complex systems), but even there most students indicated significant, if not yet full, progress. Overall, the results confirm that the STEAM approach adopted - combining theoretical knowledge with practical experiences - *facilitated substantial and relevant learning*. It validates the hypothesis that STEAM education, with its innovative pedagogies, can *improve the quality of learning* compared to traditional pathways, aligning the skills trained to the real demands of the economy and society. Therefore, *higher education institutions should systematically incorporate STEAM elements into their programs to foster both conceptual understanding and real-world competencies*, particularly in sustainability, collaboration, and problem-solving, aligning graduates' skills with the evolving needs of the labor market and society.

3. *Collaboration between stakeholders has proven to be a key element for the success of these interventions*. First of all, *student-teacher pedagogical collaboration* was emphasized through constant feedback and mutual adaptation: teachers acted more as facilitators and partners in learning, and students as active agents, providing opinions and co-creating the educational experience. This internal partnership was reflected in an open and participative learning environment, positively felt by the students (who felt that their voice mattered and that they were learning in a community). Secondly, *institutional and industry collaboration* showed its benefits: the university's involvement in an Erasmus+ consortium brought international expertise and exchange of best practices, while the link with the local business environment anchored the content in reality and gave students exposure to concrete professional perspectives. Although we did not directly quantify the impact of external factors in this study, the qualitative feedback and the context of the project clearly indicate that the *applied and industry-oriented dimension of the curriculum* - which is an

outcome of the collaboration with external parties - was a catalyst for student interest. The literature also argues that university-industry partnerships can enhance innovation and the relevance of education, and the Skills4Future results confirm this direction: students have developed skills that they perceive as valuable for their careers, feeling the link between what they learn and what is expected of them in practice. Another aspect of collaboration is *peer-to-peer learning*: this was highlighted by students as particularly useful (they learned from each other in projects), suggesting that *future implementations* could further capitalize on collaboration between students from different institutions or specializations (e.g. multidisciplinary teams).

4. *Student feedback proved essential to the continuous improvement process*, confirming the value of a structured mechanism for curricular evaluation and adjustment. Through the systematic collection of student feedback after the pilot phase and the implementation of the derived changes, the courses made visible progress in the second phase. This not only increased immediate student satisfaction, but also strengthened the *quality culture* in the institution - students saw that their feedback was taken seriously and translated into action, which encouraged them to contribute constructively. The results support the claim that *student feedback is a powerful tool for quality assurance and curriculum development*. Institutionalizing a cycle of *piloting - evaluation - assessment - adjustment - re-piloting* can lead, as we observed, to the gradual optimization of study programs, better aligning the educational offer with the needs and expectations of the beneficiaries. Moreover, such a process empowers both teachers and students: teachers become more attentive to innovation and pedagogical reflection, and students become aware that they have a role in their own training. The wider *implication* is that *universities should promote a culture of feedback and continuous improvement*, formally integrating student perspectives into curricular decisions - which is already reflected in quality assurance practices in the European Higher Education Area.

Limitations. The study's generalizability is bounded by its single-institution scope and focus on business-related courses. Outcomes rely primarily on short-term pilot and adjustment data and self-reported student feedback, which can be affected by self-selection and social desirability biases. The qualitative coding may include researcher interpretation effects despite double-coding and reconciliation. Moreover, the present phase lacks direct, systematic input from industry partners, limiting a comprehensive, multi-actor evaluation of collaboration outcomes. Future work will extend to multi-institution samples, longitudinal tracking, and the inclusion of industry-side performance indicators.

Transferability. While context matters, the intervention's core mechanisms—co-creation of curriculum content, feedback-driven iterative redesign, and applied learning anchored in real-world problems—are portable to other higher education settings. Institutions with different sizes or disciplinary mixes can adapt the model by aligning stakeholder roles, customizing feedback instruments, and calibrating the workload and difficulty of technical components to student preparedness.

Scalability and adaptation. To scale, we recommend a staged pathway: (1) pilot 1–2 courses per program with explicit learning outcomes tied to STEAM skills; (2) institutionalize a feedback loop (end-of-course surveys, open comments, focus groups) and a review board including faculty and at least one industry representative; (3) expand to adjacent courses while building a case repository and a pool of guest experts; (4) embed assessment rubrics that capture knowledge, skills, and collaboration outcomes; (5) incorporate partner feedback and student performance in authentic tasks (e.g., mini-consultancies) as part of program improvement KPIs. This staged approach allows adaptation to resource levels and disciplinary needs while preserving fidelity to the model.

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