Buletinul Ştiinţific al Universităţii Politehnica Timişoara
Seria Limbi moderne

Scientific Bulletin of the Politehnica University of Timişoara
Transactions on Modern Languages

Vol. 25, Issue 1 / 2026

The Rhetoric of Complementarity of Humanities Disciplines in Technical Universities

Cosmin BĂIAȘ[*], Caius LUMINOSU[†], Sorin SUCIU[‡]

Abstract: This paper examines the integration of humanities disciplines within technical universities through the STEAM paradigm. We argue that complementary subjects – critical thinking, rhetoric, law, and ethics – develop essential competencies beyond technical knowledge: rational analysis, civic awareness, and ethical responsibility. Drawing on legislative frameworks and educational outcomes, we demonstrate how philosophy cultivates argumentative skills and creative thinking, law prepares engineers for regulatory and civic engagement, and academic integrity fosters professional responsibility. By connecting disciplinary learning outcomes with European Commission guidelines, we advocate for interdisciplinary education that prepares engineers as informed citizens capable of addressing complex societal challenges through both technical expertise and humanistic understanding.

Keywords: complementarity, critical thinking, rhetoric, law, ethics and academic integrity, STEAM.

1. Introduction

The rhetoric of complementarity is an expression that advocates for the connection between the exact sciences and the humanities within technical universities. Our paper aims to argue the importance and implementation of humanities, in fields such as philosophy or law, based on the objectives, competences, and learning outcomes according to current legislation and teaching methodology. We think that complementary university input in the education of young people can develop

[*] Lecturer, PhD, Department. of Communication and Foreign Languages, Politehnica University of Timișoara, Romania, E-mail: cosmin.baias@upt.ro
[†] Lecturer, PhD, Department of Management, Politehnica University of Timișoara, Romania, E-mail: caius.luminosu@upt.ro
[‡] Lecturer, PhD, Department. of Communication and Foreign Languages, Politehnica University of Timișoara, Romania, E-mail: sorin.suciu@upt.ro

independent rational analysis, critical thinking based on arguments, and a civic and social awareness for citizens of democratic states who are open to information, exchange of ideas, dialogue, and constructive debate.

The STEAM concept and its use in literature are still inconsistent. In principle, it is the acronym STEM (science, technology, engineering, and mathematics) that is complemented by the arts (A).

Mejias et al. believe that, on the one hand, STEAM offers significant perspectives by emphasizing multiple ways of knowing and new paths to equitable learning. On the other hand, it is often used in theory, pedagogy, and practice in ambiguous or potentially problematic ways, in different senses. We pay particular attention to the potential for transformative learning supported by contexts in which STEAM is conceptualized as both pedagogically and instrumentally reciprocal. That is, neither STEM nor the arts are privileged over the other, but both are equally important. We link the possibilities suggested by this approach to emerging theories to understand how designing and highlighting epistemic practices related to the relevant disciplines integrated into STEAM programs can point the way toward resolving tensions in inter- and transdisciplinary learning approaches.

2025 in Romania "Diagnostic report on education and research in Romania on current achievements and implications for new reforms in the field", the so-called QX Report, an analysis on the current needs, trends and perspectives of the Romanian educational system stresses the need to implement the STEAM concept in contrast to the approach taken so far in Romanian education, based on the STEM concept. (David, 2025).

The Romanian QX Report points out the European Commission's emphasis on the outcomes of skills acquired though education: "Adult skills must emphasize STEM skills (science/S, technology/T, engineering/E, and mathematics/M), including those related to digitization, placed in an innovative entrepreneurial-dual context" (European Commission, 2025). Complementary to these, but also independent, adult skills must emphasize relevant socio-human skills (A), (1) thus contextualizing STEM as STEAM – ethical/legal, social, economic/entrepreneurial, and political, and (2) ensuring the ability to cope with current challenges as the social and economic paradigms of our civilization change (European Commission, 2025).

The European Union faces significant skills shortages, particularly in STEM and ICT fields, while the green and digital transitions generate new demands. To remain globally competitive, the European Commission stresses that the EU must foster continuous skills development. Encouraging more learners to pursue areas with high labor demand is vital, alongside ensuring all students gain transversal abilities such as critical thinking and problem-solving. Key competences, including numeracy and digital literacy, are equally essential. Strengthening higher education systems to promote these skills supports both personal and professional growth, contributing to overall quality of life.

The European Commission is advancing STEM and ICT programs through the STEAM-approach (science, technology, engineering, arts, and mathematics)

approaches. STEAM integrates disciplines by linking STEM with the arts, humanities, and social sciences, encouraging knowledge transfer and situating STEM in broader political, environmental, socio-economic, and cultural contexts. These approaches are promoted via the European Skills Agenda and the EU STEM Coalition, a Europe-wide Erasmus+-funded network dedicated to strengthening STEM education.

This paper aims to provide an insight into the implementation of the concept of complementarity as part of the STEAM paradigm by presenting examples of humanities, such as philosophy or law, taught in technical universities, based on the specific learning objectives, competences gained by the students, and learning outcomes. The presentation is complemented by bibliographical research on this topic.

2. Critical Thinking and Rhetorics

Philosophy, as a rational discipline par excellence, which has shaped the Western canon of argumentative thinking, impartial questioning, and critical evaluation of statements, can respond to the contemporary challenges that arise in front of the individual and society. Within the bachelor's program in Communication and Public Relations in the social sciences in The Polytechnic University of Timisoara, critical thinking and rhetoric cover the complementary component that comes from the humanities, more specifically from logical thinking, ethical reflection, and practical philosophy. Our conceptual approach is common to several contemporary studies (Warburton, 2007; Weston, 2027; Fosl & Baggini, 2020; Baggini & Fosl, 2024) that provide specific conceptual and methodological foundations.

If we consider that the tools of philosophy are conceptual, that is, "tools that can be used to enter, analyse, criticize, and evaluate philosophical concepts, arguments, visions, and theories" (Fosl & Baggini, 2020, xix). In this context, critical thinking is a philosophical method that helps individuals to use practical tools for argumentation, evaluation, and conceptual distinctions. Thus, philosophical thinking is complementary to scientific or rational thinking, and different from religious or artistic thinking.

If we consider that people's problems are partly conceptual and philosophical, then philosophy can provide the connection between theoretical knowledge and practical knowledge (Baggini & Fosl, 2024, xi). In this sense, philosophy provides, through critical thinking, the tools for clear thinking, and through ethics, the tools for healthy moral deliberation. In addition, thought experiments inspired by philosophy, literature, or other media sources are "especially good because they require both critical thinking and imagination" (Baggini, 2024, ix). In other words, they combine the skills of logical and rational thinking with those of creative thinking. Thought experiments designed by philosophers, artists, or scientists start from a number of imaginary scenarios or hypothetical case studies to "sharpen" ideas, test hypotheses, or assumptions. The purpose of the thought experiment is to identify one's own position in a rational manner, i.e., to conceptually clarify one's intuitions about a problem.

The general objective of the critical thinking course studied in the first semester of the first year is to use concepts, theories, and methodologies specific to rational thinking in the communication process. Firstly, the specific objectives are to develop

analysis and investigation projects specific to critical thinking and, secondly, to develop analysis and investigation projects specific to creative thinking. Thus, criticism can be understood as continuous training for freedom, civic, and moral responsibility (Iftode, 2025, 266) and represents the practical application of argumentative thinking resources in a historical context.

Professional competencies of the communication sciences grid include specific skills such as: presenting arguments in a convincing manner and providing advice on conflict management. From the perspective of learning outcomes, the competency of presenting arguments in a convincing manner involves: a) at the knowledge level, the student/graduate differentiates between types of narratives, types of reasoning, elements of logic, argumentation theory, and rhetoric or public discourse in order to classify different perspectives; b) at the skills level, the student/graduate supports persuasive messages through the structured use of arguments; and c) at the responsibility and autonomy level, the student/graduate critically analyses and adapts the speech to the context and audience. From the perspective of learning outcomes, the competence offers counselling on conflict management involves the following three levels: a) knowledge – the student/graduate identifies the type of conflict and resolves management methods; b) skills – the student/graduate applies mediation and negotiation techniques in organizational contexts; and c) responsibility and autonomy – the student/graduate decides on conflict resolution through constructive communication. Alongside these specific social science skills, there are also cross-cutting competences that include specific skills such as: creative thinking and applying knowledge of philosophy, ethics, and religion.

Rational reflection or critical thinking is a complex mental process of reasoning that helps to uncover hidden assumptions and biases. It involves courage and emotional self-management in questioning ourselves and others. At the same time, the development of the critical skills confers many benefits: better problem solving, greater confidence, speed, and accuracy in analysing complex information, along with a lower chance of being deceived or manipulated (Cottrell, 2023, 18). Thus, critical skills can be used successfully not only in academic work, but also in personal or professional life.

The general objective of rhetoric as a complementary discipline is to use concepts, theories, and methodology specific to the rhetorical analysis of the communication process. The specific objectives link the sphere of philosophy to that of communication by developing some investigation and intervention projects specific to the field of rhetoric and by developing an argumentative plan for effective communication in public communication situations.

As a discipline previously studied in the second semester of the second year, rhetoric develops professional competences that include specific ones such as: presenting arguments in a convincing manner and providing advice on conflict management; the learning outcomes from the graduate's perspective are identical across disciplines. Cross-cutting or complementary competences that are similar to those of critical thinking: think creatively and apply knowledge of philosophy, ethics,

and religion. Creative thinking involves on the three levels on the part of the learner that he acquires: a) knowledge – the student/graduate generates original ideas associated with creativity and innovation; b) skills – the student/graduate offers original ideas and innovative personalized solutions in various work contexts; and c) responsibility and autonomy – the student/graduate uses creative thinking in problem solving and in the development of interdisciplinary projects. Finally, this competence applies knowledge of philosophy, ethics, and religion it suposes from the young person: a) knowledge – the student/graduate defines fundamental concepts in philosophy, ethics, and religion that are relevant to social and professional life; b) skills – the student/graduate applies ethical, philosophical, and religious principles; and c) responsibility and autonomy – the student/graduate thinks analytically and synthetically and adopts ethically responsible behaviours in accordance with the cultural principles and values of various communities (ARACIS, 2025).

We assume that, in the face of current challenges, critical thinking is necessary about fake news and conspiracy theories by distinguishing between truth and post-truth, facts and alternative facts, misinformation and disinformation, photo and video manipulation, satire, parody, and propaganda. In the face of hybrid digital attacks, students need to have strategies for recognizing and avoiding fake news (Watson, Arp, & King, 2024, 371-380), such as the CRAAP test (acronym that stands for currency, relevance, authority, accuracy, and purpose); the ”our moves and a habit” strategy (check for previous work, go upstream, read laterally, circle back, and check your emotions); the old-school strategy, such as a sort of expertise in critical thinking, to knuckle down and test each claim. On the other hand, it is also important to know the strategies that fight with conspiracy theories through critical thinking: dive in and don't cop out; use the same standards for your beliefs that you apply to others; get independent evidence from diverse sources; look for consequences and base rates; the bigger the conspiracy, the less likely it is true; spend time on what matters and suspend belief about the rest (Watson, Arp, & King, 2024, 401-405).

In practice, educational policies should encourage the involvement of both young people and citizens in the investigation of arguments through disciplines that provide knowledge of specific concepts and rules. Thus, in technical universities, an introductory course in critical thinking can provide the foundation for self-reflection and scientific thinking through knowledge of general rules and reasoning by induction, deduction, analogy, abduction, or authority. In the next semesters, courses in rhetoric or ethics can be added in consecutive years to develop social and civic skills through interactive communication, argumentative essays, or public debates. Moreover, different modes of critical, creative, or investigative thinking help to develop a rigorous knowledge of the reasoning process and a better understanding of the sources of error, confusion, misunderstanding, and manipulation (Chatfield, 2021, 3).

3. Law – as a discipline taught in engineering study programs

The Law discipline aims to introduce students to the study and knowledge of the basic concepts and notions of law, familiarizing them with the terminology and specialized

language. It also presents the relationship between the legal system and the state, as well as the structure and functioning of the latter. In the context of a training program for future engineers. The discipline has the role of educating students in accordance with their role as citizens, beneficiaries of rights, and bearers of obligations in their relation to the state. This aspect is essential in the context of a functional democracy.

The specific objectives of the discipline are to acquire basic legal terminology, knowledge about fundamental state institutions and their functioning, and also knowledge about the action of legal norms, knowledge about the main legal acts in the Romanian legal system, and understanding the constituent elements of legal relationships and their functioning in different branches of law.

The Law course aims to achieve learning outcomes that will enable graduates to interact and participate as full members of a society based on democratic principles. These outcomes are included in the category of complementary outcomes of the study program. Thus, in terms of knowledge, the student/graduate is expected to identify, describe, and analyse concepts of general culture, social responsibility, and professional ethics. In terms of skills, the student/graduate is expected to select and apply concepts and principles of general culture, social responsibility, and professional ethics. In terms of results relating to the responsibility and autonomy of students/graduates, the intention is for them to become aware of aspects of social responsibility and professional ethics. The term "social responsibility" should be interpreted broadly in this context, thus including the legal and moral norms prevalent in society and enshrined as supreme social values in the Constitution and laws of the country. Familiarity with the concepts of the state and legal norms is fundamental to being able to apply the concepts described above.

Engineers routinely face legal, regulatory, and civic constraints that shape technical choices; teaching legal and civic literacy helps them recognize issues and respond appropriately (Gerber, 2009). Educational programs that connect law, policy, and ethics prepare engineers to protect public welfare and to make informed judgments about institutional conditions that affect societal outcomes (Zandvoort, 2010, Allain, 2018). Engineers trained to spot contract, tort, regulatory, and standards issues are less likely to make decisions that create legal exposure or public harm (Gerber, 2009). Understanding institutional and legal contexts enables engineers to evaluate whether designs promote sustainability, justice, and safety (Zandvoort, 2010). Interdisciplinary credentials, such as the study of law, increase opportunities in government, industry, and policy-advisory roles (Allain, 2018). Student demand and pedagogical reviews show ethics and civic content strengthen professional identity and decision-making (Monteiro, 2016).

Engineering decisions routinely shape public policy and democratic processes; engineers influence agenda-setting, regulation, permitting, and technical rule making, so their participation matters for policy quality (Dulin, 2002, Hyman, 2003). Preparing students to communicate across disciplines and engage with government increases the profession's ability to contribute technical insight to democratic forums (Mendoza-Garcia et al., 2012, Acevedo et al., 2009).

Engineering practice is governed by a web of contracts, tort law, professional licensing, codes, standards, and administrative regulations; curricula should teach how these frameworks interact with design and organizational practice (Gerber, 2009) (Hyman, 2003). When engineers lack legal or civic knowledge the result can be noncompliance, unexpected costs, ethical compromises, or missed opportunities to shape safer policy (David, 2025, EU Commission, 2025).

4. Ethics and Academic Integrity as a discipline taught in engineering study programs

Ethics and Academic Integrity aims to develop students' ethical competencies, critical thinking, and personal responsibility through an understanding of the values of integrity and the principles of academic fairness and justice. The discipline also seeks to train students to be able to identify, analyse, and manage problematic ethical situations in the academic environment, applying the learned principles derived from the assimilated values. This subject carries significant weight. The academic sphere is a highly specialized training area from which society's expectations are high because it is the training ground for future specialists in various fields, opinion leaders, politicians, and managers. The university is one of the main places where knowledge is created and disseminated. The values and principles of academic ethics represent a type of moral knowledge that goes beyond the academic world. For future engineers, academic ethics is a character development tool with a strong impact on their future professional work.

The main specific objectives of the discipline are related to familiarization of the students with the rules contained in the codes of academic ethics, recognition of deviation forms from these rules (plagiarism, self-plagiarism, fabrication, falsification of data, honorary authorship, etc.). At the same time, the discipline aims to train critical thinking and ethical argumentation skills through case studies and debates, as well as to develop skills in the use of anti-plagiarism tools.

The stakes of the Ethics course are twofold, as it aims not only to understand the importance of academic integrity but also to train competent, fair, and responsible professionals who act honestly in any context. The values and principles of academic ethics constitute both a framework of knowledge and a guide to moral conduct, with relevance that goes well beyond the strictly academic sphere. Once assimilated and integrated, they become a benchmark for professional and personal behaviour. Academic ethics thus functions as an essential space for shaping and strengthening the character of young people, profoundly influencing society's norms and values. The role of a university is not limited to preparing specialists in various fields of science, technology, arts or humanities, but also includes the development of personalities and the promotion of models of human conduct (Băiaș, Luminosu & Suciu, 2018).

As learning outcomes, the discipline aims to sow values and principles that constitute an ethical guide and an axiological constellation for students' academic, professional and personal life. From a competence perspective, the student should be aware of the main principles and rules of academic ethics and scientific research, of the different forms of academic misconduct, and produce original work respecting the rules

of academic ethics and integrity. In terms of abilities, students are expected to be able to correctly apply the rules of citation and paraphrasing, to assess the integrity of texts, to produce original academic work, and to make ethical decisions rationally based on moral grounds. In terms of responsibility and autonomy, students should be able to adopt responsible ethical behaviours in academic work, show respect for the intellectual work of others and for the rules codified in academic documents, and develop autonomous conduct based on integrity.

In a context where engineers are not only technical specialists, but also guardians of public safety, environmental protection and sustainable development, the discipline of Ethics and Academic Integrity takes on an essential significance. First of all, for engineering students, understanding the values of academic integrity, honesty, transparency, and fairness is the foundation of professional training that transcends the mere application of formulas or projects. Research among engineering students highlights that perceptions of plagiarism, copying, or unauthorized collaboration can directly affect not only the validity of academic outcomes, but also their preparation for real professional responsibilities (Peculea & Peculea, 2020). The seminar combined with the course, provides the space for reflection, debate and internalization of these principles, so that students directly experience real ethical dilemmas, from collaborative situations in team projects to decisions about intellectual property and responsibility to society. For example, research shows that some students have the perception that they "must pass the exam at all costs", which weakens the culture of integrity and their preparedness for their professional role (Morán, 2022).

A solid academic framework of ethics and integrity becomes indispensable when working in a broad technical environment, where mistakes or moral compromise can have significant consequences for the community and human life. As the seminal work in the field of engineering ethics emphasizes that professionals must recognize not only the technical fine-tuning but also the moral and social implications of their decisions (Davis, 2005).

The concept of technical integrity takes on particular importance for engineering students preparing to become professionals (Edwards, 2011). Technical integrity is not just about ethical conduct, but extends significantly to technical rigor, responsible ownership and reliability of the systems and equipment they design, build or operate. In Michael Edwards' conception, "technical integrity" includes "fitness for service, system safety and minimized environmental impact" (Edwards, 2009). In other words, technical integrity is the assurance that a product performs as intended, as specified, and as required by standards, without major defects, over its intended lifetime and with minimized risks. In academic work, in technical projects and papers, ensuring technical integrity involves correctly referencing sources, verifying algorithms, testing code, validating simulations, and recognizing the limitations of the tools and methodologies used. From the perspective of an engineering application, technical integrity has real implications: system lifetime, human safety, and environmental protection. Thus, academic misbehaviour – such as plagiarism or submission of unreliable data – can be

interpreted as a lack of technical integrity, with long-term consequences for the profession and society.

The discipline, therefore, aims to transform students into engineers who not only design to specification but take ethical responsibility for their actions, acting with autonomy, critical thinking, and integrity. A technical university not only creates technical specialists, but also responsible professionals who abide by codes of academic and professional ethics, helping to strengthen public confidence and the quality of the profession.

5. Conclusion

The article discussed the rhetoric of the concept of interdependence between real or social disciplines and humanities in technical universities. Study programs based on the STEM paradigm assume that science and technology offer real benefits to people, while the STEAM paradigm shift assumes that the skills and competencies developed by the humanities contribute essentially to a general understanding of both the individual and society. Furthermore, understanding our genuine humanity generates a sense of well-being by providing meaning. Interdependence, more specifically the belief in the interdependence between the natural sciences and the humanities, implies overcoming extreme and exclusive dualisms. The paradigm shift from STEM to STEAM could be understood as a kind of interdependent complementarity between the real and humanities disciplines, since humans depend on nature, but they are also the ones who ensure sustainable development and give meaning to life.

Based on complementary disciplines such as critical thinking or rhetoric, students develop reflective, strategic, and autonomous thinking from a humanistic perspective in technical universities. On this basis, they can more easily solve complex problems, be able to cultivate deep reading, information literacy, analyse carefully, check assumptions, argue, prove, contextualize, persuade, investigate, make predictions, negotiate or innovate using scepticism, logical, creative, and strategic thinking in rational decision-making. On the other side, the students should learn to avoid errors in reasoning, biased reasoning, fake news, and conspiracy theories that are increasingly present today through AI and social media (Chatfield, 2021, Cottrell, 2023, Watson, Arp, & King, 2024).

Teaching law and civics yields measurable professional and societal benefits, such as reduced legal risk, improved project outcomes, stronger public trust, and higher-quality policy informed by technical expertise (Gerber, 2009, Dulin, 2002, Allain, 2018). Educated engineers can anticipate regulatory impacts, engage constructively with democratic institutions, and help shape legal frameworks and systems that better serve justice and sustainability.

Teaching academic ethics in technical universities plays an essential role in forming responsible professionals capable of integrating both technical rigor and moral judgment in their future work. The values of integrity, honesty and responsibility form the foundation of a professional culture in which technical competence cannot be separated from the social consequences of engineering decisions (Davis, 2005;

Edwards, 2009). By understanding the forms of academic misconduct, their implications and practicing ethical argumentation in real-life contexts, students develop the ability to make autonomous and well-informed decisions, both in academic work and in technical projects with impact on public safety and the environment (Peculea & Peculea, 2020; Morán, 2022). In this way, the discipline contributes directly to the formation of technical and professional integrity, an indispensable element in building public trust in engineers and in the quality of the results of their work.

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