MATERIALS SCIENCE MA(S)TERS

developing a new master's degree

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FROM CONCEPT TO IMPLEMENTATION

A COMPREHENSIVE GUIDE TO THE MATERIALS SCIENCE MASTERS PROGRAMME

MATERIALS SCIENCE MASTERS

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UNIVERSITY OF SILESIA IN KATOWICE

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Dear Readers,

It is with great satisfaction that we place in your hands the methodological guide to the Materials Science Masters programme, which is the result of intensive collaboration between an international team comprising four universities: the University of Silesia in Katowice, Poland; Ivan Franko National University of Lviv, Ukraine; the University of Zhilina, Slovakia; and Afyon Kocatepe University, Turkey. This unique initiative has not only resulted in the creation of a unique international educational programme, but has also brought a number of benefits to all the institutions and their staff involved.

International cooperation has enabled us to exchange invaluable experience and expertise. Each university brought its unique vision, experience, perspectives and expertise, which contributed to a unique programme of unprecedented comprehensiveness. As a result, our team was able to broaden its horizons in the areas of didactics, culture, organisation, as well as gain new skills in curriculum design and establish lasting international relationships.

The process of creating the programme has been a catalyst for raising educational standards at all partner universities. It inspired us to introduce innovative teaching methods and incorporate the latest curricular content in cooperation with a potential stakeholder such as industry. In addition, the collaboration has opened up new opportunities to undertake future joint research projects, exchange students, academic staff and laid the foundation for the opening of an international master's degree programme in materials engineering.

The result of international synergy, our programme is designed to educate versatile professionals ready to meet the challenges of the rapidly evolving world of materials technology and to compete effectively in the international job market. It consists of 11 key thematic blocks, each carefully designed to provide students/students not only with in-depth theoretical knowledge but also with the practical skills needed in modern materials engineering.

The guide not only provides details of the innovative didactic programme, but also inspires reflection on the value of international cooperation in education and the teaching culture of universities. The experiences developed can serve as a model for future international educational initiatives, not only in the field of materials engineering, but also in other disciplines.

We invite you to explore the opportunities offered by our programme - a gateway to a career in the world of advanced materials technology, created through the strength of international academic collaboration.

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The guide we put in your hands is a tool to support the implementation of the programme, offering detailed guidance and methodology to help you successfully implement this innovative approach to materials engineering education.

With kind regards,

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1. Design of the Study Programme

1.1. Concept of Education

The proposed concept of the Materials Science Masters programme is based on an approach that puts the master's thesis at the centre of the educational process. Students start working on their master's project as early as the first semester of their studies, choosing its topic in collaboration with companies, research institutions or research teams of the university where the education programme is being implemented. This central approach ensures continuity and consistency in the educational process, while allowing students to be deeply involved in the practical applications of the knowledge they have acquired.

A key element of this concept is the personalisation of the study path. The study programme is characterised by flexibility, offering a wide choice of subjects. Students, supported by their mentors (selected from among the academic staff), create an individual study path that best suits their interests, always taking into account the subject matter of their thesis.

A compulsory research and development (R&D) block is an integral part of the education process. Within the block, students participate in specialised classes and workshops covering research methodology, experiment design, data analysis and research project management. The programme is enriched with elements of entrepreneurship, including classes on setting up and running technology start-ups, protection of intellectual property and commercialisation of research. These additional components of the curriculum are designed to equip students with the skills necessary to turn innovative ideas into real business ventures.

An important element of the proposed educational concept is the mentoring system. The mentor acts as a guide and advisor, supporting the student's academic and professional development throughout the study period. Regular mentoring meetings, organised both for the whole group and individually as necessary, provide students with valuable advice on choosing an educational path, completing a thesis and career planning. Mentors also help to develop professional networks, identify internship or placement opportunities and deal with potential academic challenges. The group or individual mentoring model supports students in achieving their educational and professional goals and promotes collaboration and exchange of experiences between participants in the education programme.

Students, together with their mentors, choose the most appropriate forms of documentation and presentation of the progress of their ongoing research. This may include regular reports, multimedia presentations, interactive online portfolios or research blogs. The method of documentation is decided jointly by the student and mentor, allowing for customisation according to the individual needs of the project, the preferences of the participants and the specifics of the research. In this way, students learn how to communicate their research findings and scholarly activities in a way that can be understood by a variety of audiences, including professionals in the field. Additionally, students learn how to use these forms of documentation to potentially demonstrate the commercial potential of their research, which contributes to the development of their entrepreneurial skills.

An innovative element of this concept is the integration of skills to enhance so-called 'employability skills' in the course subjects. Competences such as communication, teamwork, project management and presentation skills are systematically integrated into the curriculum of individual subjects. For example, in selected modules, students work on group projects that develop not only their technical knowledge, but also their cooperation and time management skills. Presentations of laboratory results are used to improve communication skills, and regular progress reports on the master's thesis improve the ability to produce technical texts.

The training programme places a strong emphasis on developing engineering competence through a large number of laboratory and project activities and an interdisciplinary approach to the topics covered in class. Using advanced equipment and the latest technological solutions, students can keep abreast of developments in their discipline.

Developing engineers who are ready to meet the unforeseen challenges of the future is a key pillar of the curriculum. Every aspect of the degree - from lectures to projects - is designed to develop students' ability to think innovatively and adaptively. Practical classes go beyond the presentation of current technologies to inspire deeper reflection on future trends in materials engineering. Learning projects, based on real industry problems, pose complex challenges to students, motivating them to develop innovative solutions with potential global relevance. This approach not only prepares future engineers to deal with current challenges, but also equips them with the skills necessary to shape the future of their field.

Cooperation with the business environment is the cornerstone of the study programme. A key role in this process is played by the Curriculum Council, which comprises experts from the university, representatives from businesses, research centres and alumni. The Council regularly reviews and recommends changes to the curriculum to reflect the latest technological developments and respond to the changing needs of the industrial sector.

The activity of the Programme Council, combined with projects carried out in cooperation with companies and regular meetings with business representatives, ensures that education is oriented towards real market requirements. Compulsory internships and placements in companies are an integral

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part of the programme, giving students the opportunity to confront theoretical knowledge with practical challenges in an industrial environment.

The programme is subject to continuous improvement thanks to its integration with the comprehensive Quality Assurance System in place at the universities implementing this educational initiative. This system encompasses a number of precisely designed procedures aimed at continuously improving educational standards.

As part of the system, periodic surveys are conducted among key stakeholder groups, i.e. students, academic staff, graduates and employers. The opinions collected in this way are an invaluable source of feedback, enabling the identification of areas for improvement and indicating new directions for the development of the programme.

In parallel, the programme is subjected to an annual in-depth evaluation carried out by an interdisciplinary team comprising members of the Programme Board and invited external experts. This multifaceted review allows the programme content to be systematically updated, ensuring that it is up-to-date and relevant to the dynamically changing requirements of the labour market and technological advances.

1.2. A Methodology for Curriculum Development: A Hierarchical Approach

The Materials Science Masters project uses a hierarchical approach to curriculum development. The methodology ensures consistency, transparency and efficiency throughout the educational process.

At the highest level, general learning outcomes are defined for the entire study programme (the learning outcome of the programme). These outcomes form the foundation on which subsequent, more detailed levels are built. They include broad learning objectives that define the knowledge, skills and competences that a graduate should possess upon completion of the Materials Science Masters.

The learning outcomes for the Materials Science Masters programme were developed on the basis of extensive stakeholder research, with a particular focus on industry partners, and the extensive experience of the collaborating partner universities. The process was extremely comprehensive and took into account a variety of perspectives, ensuring that the programme meets the real needs of the labour market and the latest trends in materials science.

Consultation on programme assumptions was also carried out at conferences organised during the project. These events provided a platform for discussion and exchange of views between representatives of academia, industry and other key stakeholders. Of particular importance, all defined learning outcomes are fully compliant with Level 7 of the European Qualifications Framework (7 EQF). This ensures that the Materials Science Masters programme meets European standards for Masters level education, ensuring that graduates acquire the advanced knowledge, skills and competences required at this level of education.

The Materials Science Masters programme is divided into thematic blocks, grouping thematically related subjects. Each thematic block is compulsory, providing comprehensive coverage of key knowledge areas, but within the blocks students have the option to select specific subjects. This approach allows the programme to be personalised according to individual interests, chosen educational pathway, and career plans, while maintaining the coherence and integrity of the entire course of study.

Specific learning outcomes have been defined for each thematic block (the learning outcome of the thematic blocks). These outcomes are more specific than the general programme outcomes, but still broad enough to cover a variety of aspects of the thematic area. Importantly, the learning outcomes at the level of the thematic blocks are a direct specification and development of the directional outcomes. This means that each thematic block effect is closely linked to one or more of the directional effects, thus ensuring coherence and a logical progression in the learning process.

At the lowest level of the hierarchy are the individual subjects assigned to thematic blocks. For each subject, instructors develop detailed syllabuses, carefully selecting content and teaching methods that enable the learning outcomes defined for the subject blocks to be met in the context of the specific content of the course. In the case of the Materials Science Masters project, each partner university developed 20 syllabuses, guided by the results of extensive stakeholder research, with a particular focus on industrial partners. Each partner university brought its unique knowledge and experience to the process, resulting from its research, collaboration with industry and previous teaching activities.

The Materials Science Masters curriculum development methodology used provides a logical and coherent structure that supports effective teaching and learning. It allows for the systematic building of students' knowledge and skills, while ensuring that each element of the programme has a legitimate place in the wider educational context. At the same time, it allows flexibility in the selection of specific content and teaching methods within individual subjects, enabling adaptation to the latest trends in materials engineering and the needs of the labour market.

1.1. Learning Outcomes

Course learning effect code	Learning outcomes On completion of the second degree with a general academic profile in the Materials Science Masters programme, the graduate will:	PRK level II characteristic codes EN
	NEWS	
MSM_W01	has an in-depth and structured knowledge, covering key issues and selected aspects of advanced specific knowledge from the various disciplines that form the theoretical foundation of materials engineering.	2018_P7S_WG
MSM_W02	has in-depth, structured and theoretically grounded knowledge of the various groups of engineering materials and is versed in current and prospective areas of their application.	2018_P7S_WG
MSM_W03	has an in-depth, structured and theoretically underpinned knowledge covering the complex structure-property relationships of engineering materials, providing the theoretical foundation necessary for the shaping, manufacturing, design and modelling of engineering materials with specific properties.	2018_P7S_WG
MSM_W04	has an in-depth, structured and theoretically grounded knowledge of the methods and techniques that are used to produce, shape the form, structure and properties of engineering materials.	2018_P7S_WG
MSM_W05	has in-depth, structured and theoretically grounded knowledge of materials testing methods and the construction of scientific and testing apparatus necessary for the assessment of the structure and properties of engineering materials.	2018_P7S_WG
MSM_W06	knows and understands the complex processes involved in the life cycle of technical equipment, facilities and systems, with particular reference to the deterioration processes of engineering materials and measures to prevent or delay these processes.	2018_P7S_WG
MSM_W07	has an in-depth, structured and theoretically underpinned knowledge of the methodology of selection of engineering materials, taking into account the complex relationships between their structure, properties and performance requirements.	2018_P7S_WG
MSM_W08	has an in-depth and structured knowledge of development trends and latest developments in the field of advanced engineering materials, as well as innovative technologies for their production and techniques for shaping their properties, with critical consideration of the principles of sustainable development and the complex challenges of modern civilisation.	2018_P7S_WG, 2018_P7S_WK
MSM_W09	Has a structured and theoretically underpinned knowledge of computer-aided engineering and demonstrates a deep understanding of the potential for the use of selected ICT and IT tools in materials engineering.	2018_P7S_WG
MSM_W10	has an in-depth and structured knowledge of the protection of industrial property, intellectual property and copyright.	2018_inż_P7S_WK

MSM_W11	has an in-depth and structured knowledge of the principles for the creation and development of various forms of entrepreneurship related to materials engineering in the broadest sense.	2018_P7S_WK
MSM_W12	has an in-depth and structured knowledge of research methodology in the field of materials engineering, including in the context of carrying out research and development projects.	2018_P7S_WG, 2018_P7S_WK
OOD.2024_ W01	has an in-depth knowledge of selected scientific methods and is familiar with issues characteristic of a selected scientific discipline unrelated to his/her major field of study	2018_P7S_WG, 2018_P7S_WK
	SKILLS	
MSM_1U01	is able to acquire information from a variety of sources, including scientific literature, databases and technical standards, select, evaluate and critically analyse, synthesise and creatively interpret information appropriately, and then present the results clearly and comprehensibly.	2018_P7S_UW
MSM_1U02	is able to formulate and test hypotheses relating to simple research problems involving, in particular, the shaping, manufacture, design, modelling and selection of engineering materials with specific properties.	2018_P7S_UW
MSM_1U03	is able to apply existing or develop new methods and tools to identify, formulate and solve research problems and tasks of an engineering nature, critically evaluating their usefulness and effectiveness under conditions of incomplete predictability.	2018_P7S_UW, 2018_inż_P7S_UW
MSM_1U04	is able to select and use information and communication technology, as well as computer methods and tools, to formulate and carry out tasks, including tasks of an engineering nature.	2018_P7S_UW, 2018_inż_P7S_UW
MSM_1U05	is able, according to a given specification, to design a simple device, object, system or process, typical of materials engineering, using appropriate design methods, techniques and tools.	2018_P7S_UW, 2018_inż_P7S_UW
MSM_1U06	is able, in formulating and solving tasks, including those of an engineering nature, to make an initial economic analysis and critically evaluate non-technical aspects, including in the context of global civilisation challenges.	2018_P7S_UW, 2018_inż_P7S_UW
MSM_1U07	is able, using appropriately adapted specialist terminology, to communicate with a variety of audiences, including discussion and debate, presenting and analysing various aspects of materials engineering.	2018_P7S_UK
MSM_1U08	is able to prepare documentation for tasks, including tasks of an engineering nature, and to present the results of his/her work using appropriate methods and tools.	2018_P7S_UK
MSM_1U09	is able to work individually and in teams, including as a leader leading a team.	2018_P7S_UO
MSM_1U10	is able to plan and implement his/her own lifelong learning independently and to guide and support others in doing so.	2018_P7S_UU
OOD.2024_ U01	has advanced skills of posing research questions and analysing problems or solving them in practice on the basis of acquired content and practical experience and skills in a chosen discipline of science not related to the leading discipline of the degree programme	2018_P7S_UW

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SOCIAL COMPETENCES		
MSM_2K01	demonstrates the ability to critically appraise their knowledge and perceived content, recognises the role of knowledge in solving complex cognitive and practical problems and is prepared to seek expert advice when encountering difficulties in solving a problem independently.	2018_P7S_KK
MSM_2K02	is willing to be actively involved in building public awareness of the role and importance of materials engineering, promoting its achievements and initiating public interest activities in this area.	2018_P7S_KO
MSM_2K03	is ready to fulfil professional roles, demonstrating responsibility towards the duties assigned, acting in accordance with ethical principles and professional standards.	2018_P7S_KR
MSM_2K04	is ready to think and act entrepreneurially and innovatively in the field of materials engineering, actively seeking new solutions, including in the context of the challenges and dilemmas of modern civilisation.	2018_P7S_KO
OOD.2024_ KS01	Understands the need for an interdisciplinary approach to solving problems, integrating knowledge or using skills from different disciplines and practising self-education to deepen acquired knowledge	2018_P7S_KK

1.3. Profile of the Graduate

In the previous chapter we presented the specific learning outcomes resulting from the developed international study programme. They define the knowledge, skills and social competences acquired by the graduate/student during the four-semester master's programme. They indicate the specific learning objectives that the students/graduates should achieve upon completion of the programme, while offering tools to assess the progress, efficiency and effectiveness of the education.

What emerges from these descriptions is an outline of the silhouette of a graduate of the master's programme in materials engineering. It comprehensively captures the range of skills, knowledge and competencies successively acquired during the course of study, and shows how these abilities translate into readiness for a variety of professional roles in the rapidly developing world of materials technology. The graduate silhouette takes into account both the theoretical and practical aspects of education, as well as preparation for continuous professional and personal development. Through this multidimensional perspective, a complete picture of the graduate profile is formed, allowing for a broader understanding of how educational goals translate into real competences, preparation for professional challenges and competing in the international labour market.

Graduates of the offered master's programme in materials engineering are versatile specialists, well prepared to take on a variety of professional roles in the rapidly developing world of materials technology. Their professional profile is characterised by the following features:

1. **Targeted theoretical and practical knowledge:** graduates have a thorough knowledge of materials engineering based on the basic sciences. This includes both classical and state-of-the-art engineering materials. Their theoretical knowledge is closely linked to practical skills, translating into its effective application in real-world conditions of both industry and research. They understand the complex relationships between the structure, properties and functionality of materials and their performance under practical operating conditions.
2. **Advanced research skills:** Through intensive practical laboratory classes and participation in research projects, graduates are prepared to work in advanced research laboratories. They are able to plan and conduct complex experiments, analyse and interpret results and formulate constructive scientific conclusions. They are familiar with state-of-the-art techniques and methods for the characterisation of materials . They are able to apply them in practice.
3. **Competence in computational methods:** Graduates are skilled in advanced computational methods and computer simulations, enabling them to optimise computer-aided design,

manufacturing and materials testing processes. They are able to effectively use computer and computational tools to model the properties of materials and predict their behaviour under varied real-world conditions.

4. **Skills in reliability and material degradation analysis**: graduates are able to assess and improve the reliability of material systems, taking into account economic and environmental aspects. They are able to analyse the degradation processes of different types of materials and develop strategies to prevent failures. They are able to design solutions to increase the durability and reliability of materials.
5. **Technology transfer skills**: graduates understand the process of knowledge and technology transfer from laboratory conditions to a real industrial setting. They are able to effectively value the commercialisation potential of new material solutions and participate in implementation processes in an industrial environment.
6. **Analytical and critical thinking skills**: The programme trains professionals capable of critically evaluating and optimising material properties and technological manufacturing and processing processes. Graduates are able to analyse complex engineering problems, evaluate different solutions and make critical decisions. They are able to interpret research results, use them to optimise engineering designs effectively minimising the occurrence of dysfunctions in practical applications.
7. **Innovation and creativity**: graduates are prepared to actively participate in the development of new materials technologies. Their creative approach and ability to think outside the box allow them to propose innovative solutions in the field of materials engineering. They are open to new ideas and are able to combine knowledge from different fields to create new and improved solutions.
8. **Competence in sustainability**: Graduates are environmentally aware and are able to design materials and processes with sustainability in mind, including the SDGs (Sustainable Development Goals) set by the United Nations. They understand the importance of the life cycle of materials and can assess the environmental, economic and social impact of new materials. They are prepared to develop SDGs-compliant sustainable engineering solutions.
9. **Communication and teamwork skills**: The programme trains professionals who are able to communicate effectively in both academic and industrial settings, as well as with external stakeholders. Graduates are prepared to work in international and intercultural research and project teams. They are able to present and discuss their research results, prepare scientific

reports and develop technical documentation, and communicate effectively with other professionals in the field.

10. **Entrepreneurship:** graduates demonstrate an entrepreneurial mindset. They are prepared to start and run their own business based on innovation and sustainability. They understand the business aspects of implementing new material technologies and are able to assess the market potential of innovative solutions. They are able to create business plans for their own projects.
11. **Project management competencies**: Graduates are skilled in managing research and development projects. They are able to plan and coordinate teamwork, manage resources, people and time, and achieve project goals effectively.
12. **Adaptability and readiness for continuous learning:** In the face of rapidly changing technologies, graduates are prepared to continuously update their knowledge and skills. They have the flexibility to adapt to new professional challenges. They are aware of the importance of lifelong learning and are able to expand their knowledge independently.
13. **Ethical and social awareness**: graduates are aware of their professional responsibility and understand the ethical and social implications of using advanced materials. They are prepared to make decisions in a professional work environment.
14. **Intercultural competence**: Thanks to the experience of working in international teams, graduates are prepared to function in an intercultural professional environment. They understand and respect cultural differences, allowing them to effectively lead and undertake collaborative international projects.
15. **Intellectual property protection skills**: Graduates are familiar with the basics of intellectual property law. They are aware of and understand the importance of patent protection in the field of materials engineering. They are able to identify opportunities for a potential patent solution and participate in the process of preparing patent applications.

The knowledge, competences and skills acquired shape the silhouette of our graduates ready to work in a variety of sectors such as:

- Advanced research laboratories of scientific and academic institutions
- Research and development departments of industrial enterprises
- Companies involved in the design and manufacture of innovative materials
- High-tech companies, including aerospace, automotive, electronics
- Institutions concerned with environmental protection and sustainable development
- Own technology start-ups
- Consulting companies operating in the field of materials science

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- Standardisation and certification institutions Technology transfer centres
- International research organisations

Graduates of our programme are prepared for a variety of professional roles such as:

- Materials engineer in industry
- Researcher-scientist in academic or industrial institutions
- Material characterisation specialist
- New product development engineer
- Materials engineering consultant
- Quality control specialist
- Production process engineer
- Research and development project manager
- Entrepreneur in the advanced materials technology sector
- Sustainability specialist in materials engineering

In summary, graduates of our programme are specialists, combining in-depth theoretical knowledge with practical skills, ready to take on complex engineering challenges, actively shaping the future of materials technology, following the rapidly changing trends of contemporary materials requirements. Their comprehensive background, combined with analytical skills, creativity, social, environmental and ethical awareness, makes them good candidates for employees in diverse economic sectors, entrepreneurs, innovation leaders Graduates are also prepared to continue their education at doctoral level. Their solid theoretical foundation and practical research experience provide an excellent starting point for advanced scientific and implementation research .

2. Implementation of the Study Programme: Curriculum Content

The MSc programme in Materials Engineering is designed to provide students with the specialised knowledge, skills and social competences necessary to work in industry, research institutes or to pursue a research career in doctoral studies in four semesters, each comprising 30 ECTS credits. The structure of the programme is based on 12 subject blocks, which allow students to choose their subjects and construct an individual learning path. Students are required to complete all thematic blocks, but have the opportunity to personalise their learning path by selecting specific subjects within each block. This choice is supervised and approved by the academic supervisor to ensure that the learning outcomes assigned for the subject block are met. For students who prefer a more structured approach, pre-defined learning paths are also available that contain a set of subjects that guarantee the achievement of the required competences.

In the first semester, students complete the following thematic blocks:

Thematic Block 1: Advanced material characterisation methods (8 ECTS)

Theme block 2: Advanced engineering materials (12 ECTS)

Thematic Block 3: R&D in Materials Engineering - Part 1 (6 ECTS)

Thematic Block 4: Fundamental aspects of materials science (4 ECTS)

In the second semester, the programme includes:

Thematic Block 5: Computational methods and their applications in materials science (6 ECTS)

Thematic Block 6: Materials Testing Methods and Failure Analysis (12 ECTS)

Thematic Block 7: Materials and Manufacturing (12 ECTS)

The third semester is:

Thematic Block 8: Applied Materials Science (12 ECTS)

Thematic Block 9: R&D in Materials Engineering - Part 2 (8 ECTS)

Thematic Block 10: Proffesional Practice (10 ECTS)

The fourth semester includes:

Thematic Block 11: Research Project – Master Thesis (24 ECTS)

Thematic Block 12: Humanities and Social Sciences Module (6 ECTS)

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2.1. Description of the Thematic Blocks and the Assigned Learning Outcomes

Thematic blocks are key elements of the programme structure, grouping subjects with similar themes and enabling students to acquire specialised knowledge, skills and social competences in selected areas of materials engineering. Each thematic block has learning outcomes assigned to it, specifying the expected learning outcomes to be achieved by the student after passing the subjects included in the block.

Detailed information on the individual subjects included in each block, as well as guidance for instructors, has been developed separately. These materials, which are an integral part of the study programme, were prepared as part of the Intellectual Output 2 project and are made available as separate documents.

2.1.1. Thematic Block 1: Advanced Material Characterisation Methods

The subject block is a fundamental component of the MSc programme, offering an advanced and comprehensive approach to materials characterisation. The programme has been structured to provide students with the comprehensive theoretical knowledge and practical skills necessary to effectively conduct materials research at an expert level.

The block's modular structure enables students to personalise their educational pathway, allowing them to select the components that most closely align with their scientific interests and career aspirations. Each module includes an in-depth study of the physical principles, application methodologies and limitations of individual characterisation techniques, providing a thorough understanding of both the theoretical underpinnings and the practical aspects of their use.

An integral element of the programme is the synthesis of academic lectures with intensive laboratory sessions, enabling students to directly apply the acquired theoretical knowledge in practice. Practical classes are conducted with the use of advanced research apparatus, allowing the development of technical competences necessary in modern research and industrial laboratories.

The programme places particular emphasis on the development of analytical and critical thinking skills. Students are trained to assess the appropriateness of a variety of characterisation methods in relation to specific materials and research contexts, a key competency for strategic decision-making in scientific and industrial settings.

The thematic scope of the block covers a broad spectrum of topics. This diversity provides a comprehensive preparation, making graduates versatile specialists in materials characterisation.

Upon completion of the block, students acquire a set of highly specialised competences that are particularly valued in both academia and industry. Students are prepared to take on complex research challenges, participate in innovative scientific projects and function effectively in a dynamic professional environment.

The programme does not limit itself to presenting the current state of the art, but also stimulates reflection on future developments in the field of materials characterisation. This innovation-oriented perspective prepares students to actively participate in shaping the future of the discipline and to adapt to rapidly changing technological requirements.

Knowledge

- AMMC_0W01: The student has an in-depth and structured knowledge of the principles of operation and applications of selected research methods and specialised scientific and research apparatus used to identify and describe the structure of materials and to study their properties.
- AMMC_0W02: The student knows and understands current trends in the development of testing techniques for characterising the structure and properties of materials and is able to evaluate their potential applications.
- AMMC_0W03: The student analyses and evaluates the appropriateness of different characterisation methods in relation to specific materials and research contexts.
- AMMC_0W04: The student has an in-depth knowledge of the methodology of conducting scientific research in materials characterisation.
- AMMC_0W05: The student knows and understands the economic, legal and other considerations of different types of materials characterisation activities, including the principles of industrial property and copyright protection.

Skills

- AMMC_0W06: The student identifies current trends in the development of testing techniques for characterising the structure and properties of materials and evaluates their potential applications.
- AMMC_1U01: The student is able to select and apply appropriate characterisation methods to specific materials and research contexts.
- AMMC_1U02: The student is able to critically analyse and evaluate existing technical solutions and propose their improvements in the field of materials characterisation.

- AMMC_1U03: The student is able to communicate on specialist topics in materials characterisation with a diverse range of audiences.
- AMMC_1U04: The student is able to interact with others as part of teamwork and take a leading role in teams conducting materials research using advanced characterisation techniques.

Social competences

- AMMC_2K01: The student is prepared to critically evaluate their knowledge and perceived content in materials characterisation and recognise the importance of knowledge in solving cognitive and practical problems.
- AMMC_2K02: The student is ready to initiate action in the public interest, to think and act in an entrepreneurial manner in the implementation of innovative material characterisation techniques, including in the context of achieving sustainable development goals.

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2.1.2. Thematic Block 2: Advanced Engineering Materials

The 'Advanced Engineering Materials' block is a comprehensive set of modules designed to enhance students' knowledge of contemporary engineering materials. Topics in the block cover a broad spectrum of engineering materials, including composites, ceramics, functional polymers, advanced metal alloys and modern materials such as metamaterials and nanostructures. The modular architecture of the block allows for an optimised learning pathway, tailored to students' individual research preferences and career aspirations. Each module provides a solid foundation in materials science. On these foundations, students will learn advanced aspects of engineering materials, covering their characteristics, applications and innovative manufacturing and processing methods. The programme integrates the latest developments in science and technology with a practical approach, enabling students to explore the latest trends and technologies in engineering materials. The aim is to prepare students to function effectively in professional and scientific environments, both nationally and internationally. There is a strong emphasis on sustainability in the programme. Students will explore materials and technologies that reduce the negative impact on the environment, promoting green and sustainable engineering solutions. The block programme also considers environmental, economic and social aspects, preparing students to develop innovative solutions that support sustainability. The programme involves the development of communication skills, which are essential to effectively present research findings, write scientific and technical reports and communicate with other professionals in the field. The block programme not only imparts up-to-date knowledge, but also inspires thinking about future trends in engineering materials. With an emphasis on innovation, students are prepared to actively shape the future of the discipline and to respond flexibly to rapidly evolving technological requirements.

Knowledge

- AEM_0W01: The student has a structured and theoretically supported knowledge of selected groups of advanced engineering materials and is versed in current trends and prospective developments in the area of their application.
- AEM_0W02: The student will have the advanced theoretical knowledge necessary for the shaping, fabrication, design and modelling of engineering materials with specific properties, based on a deep understanding of the relationship between the structure and properties of these materials.

- AEM_0W03: The student understands the importance of the development of advanced engineering materials in the context of sustainable development, taking into account their impact on the environment, economic development and social well-being.

Skills

- AEM_1U01: The student is able to analyse and evaluate the properties of different groups of advanced engineering materials and identify potential areas of application.
- AEM_1U02: The student is able to formulate and solve selected problems involving, in particular, the shaping, manufacture and selection of advanced engineering materials with specific properties.
- AEM_1U03: The student is able to apply information and communication technologies (ICT) to solve problems of a research or engineering nature in the area of advanced materials, selecting appropriate tools depending on the nature of the task.
- AEM_1U04: The student is able to communicate effectively on topics related to advanced engineering materials, including presenting research results and leading discussions with specialists in the field.
- AEM_1U05: The student is able to lead the work of an advanced engineering materials research team and to interact with others as part of a team effort.
- AEM_1U06: The student is able to independently plan and implement his/her own lifelong learning in the field of advanced engineering materials and to guide others in doing so, taking into account the rapidly changing state of knowledge and technology in the field.

Social competences

- AEM_2K01: The student is prepared to critically evaluate their knowledge of advanced engineering materials and to recognise the importance of knowledge in solving cognitive and practical problems in the field.
- AEM_2K02: The student is ready to think and act in an entrepreneurial and innovative way, seeking new solutions in the field of engineering materials, taking into account sustainability aspects.

2.1.3. Thematic Block 3 and 9: R & D in Materials Engineering

The 'Research and Development in Materials Engineering' thematic block is a key part of the MSc programme, aiming to comprehensively prepare students for advanced research and work in the rapidly growing industry sector related to materials engineering in its broadest sense. Through participation in the three modules in this thematic block, students acquire knowledge, skills and social competencies aimed at strengthening their position in the competitive labour market.

The aim of the first module, 'Introduction to Research Projects', is to introduce students to the fundamental aspects of conducting scientific research. It covers research methodologies, planning experiments, data analysis and the principles of editing scientific reports. Students learn how to formulate research hypotheses and conduct research in accordance with the highest standards of scientific ethics. The module provides the basis for further development of students' research competence.

The second module, 'Industrial Visits and Lectures', offers students a unique opportunity to interact directly with the industry sector related to materials engineering in its broadest sense. Through visits to companies and/or lectures given by experienced industry professionals, students gain insight into current challenges and market needs. This learning experience supports the process of selecting thesis topics that correspond to real industry issues. In addition, this module provides an opportunity to make valuable contacts with potential employers and mentors.

The third module, 'International Teamwork and Communication in a Foreign Language', focuses on the development of key soft skills that are essential in the globalised scientific and industrial world. Students are introduced to the methodology of working in projects carried out in cooperation with foreign academia or companies, allowing them to gain valuable experience in working in multicultural teams. These classes improve language skills and develop the ability to communicate and cooperate effectively in an international context.

The thematic block 'Research and Development in Materials Engineering' is a carefully designed block that integrates theoretical knowledge with practical skills, preparing students to address the challenges of modern materials engineering. Graduates of this thematic block will be well prepared for careers in both academia and industry, with a solid foundation in innovative research and the implementation of advanced materials solutions.

Knowledge

- RD_0W01: The student knows and understands the basic principles of planning and managing research projects in materials engineering, in both academic and industrial contexts.

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- RD_0W02: The student knows and understands the structure and components of a research project, including objectives, hypotheses, methodology, timetable and potential applications in industry.
- RD_0W03: The student knows and understands the economic, legal and ethical conditions of research and innovation activities in materials engineering, including the principles of intellectual property protection and cooperation with industry.

Skills

- RD_1U01: The student is able to carry out a critical analysis and select a research problem, integrating knowledge of recent research trends and industry needs.
- RD_1U02: The student is able to formulate an objective and hypotheses for a research problem, taking into account both scientific aspects and industrial needs in the area of materials engineering.
- RD_1U03: The student is able to develop a preliminary research plan, selecting appropriate research methods and techniques, taking into account available academic and industry resources.
- RD_1U04: The student is able to prepare and present a conceptual solution to a selected research problem in the form of a presentation, taking into account the potential industrial applications of the proposed solutions.
- RD_1U05: The student is able to collaborate in a team to analyse research and industrial problems, understanding the roles of the different stakeholders in the research and implementation process.
- RD_1U06: The student is able to identify his/her own educational needs and plan a learning path in the context of a chosen research problem and future career.

Social competence

- RD_2K01: The student is prepared to critically evaluate their own research ideas and recognise the importance of expertise from both academia and industry in research planning.
- RD_2K02: The student is ready to initiate research activities to solve social and technological problems in the area of materials engineering, taking into account the needs of industry.
- RD_2K03: The student is prepared to fulfil the role of researcher and engineer responsibly, observing professional and scientific ethics in the context of collaboration with industry.

- RD_2K04: The student is willing to continuously update his/her knowledge on new methods and trends in materials engineering, both in research and industrial aspects.
- RD_2K05: The student is prepared to think and act in an entrepreneurial manner, identifying the commercial potential of proposed material and technological solutions within the research problems undertaken.

2.1.4. Thematic Block 4: Fundamental Aspects of Materials Science

The subject block 'Fundamental Aspects of Materials Science' focuses on deepening students' knowledge of materials science in the broadest sense. It consists of thematic modules that students can choose from, personalising their learning pathway. Each module is designed to deliver learning outcomes that ensure the integration of knowledge from other disciplines, including in particular mathematics, physics and chemistry, to provide the solid foundation necessary to understand complex processes and phenomena in materials. As a result, students are prepared to identify, formulate and propose solutions to selected engineering problems using an interdisciplinary approach. The implementation of the block not only deepens the theoretical foundations of materials engineering, but also places great emphasis on the practical application of the knowledge gained. Students will acquire practical skills such as developing problem-solving strategies, preparing a workstation, carrying out assigned tasks and producing documentation of their completion.

Knowledge

- FAMS_0W01: The student knows and understands to an in-depth degree the theoretical foundations of materials science, integrating knowledge of mathematics, physics and chemistry.
- FAMS_0W02: The student knows and understands the complex processes and phenomena occurring in materials, and is able to analyse and interpret them using an interdisciplinary approach.
- FAMS_1U01: The student is able to integrate knowledge from different scientific disciplines to identify, formulate and solve complex engineering problems in the field of materials science.

Skills

- FAMS_1U02: The student is able to develop a theoretically sound strategy for solving a materials engineering problem using an interdisciplinary approach.
- FAMS_1U03: The student is able to plan and carry out advanced research or experiments related to the analysis of materials, interpreting the results obtained and drawing conclusions.
- FAMS_1U05: The student is able to plan and implement his/her own lifelong learning independently, especially in the context of the rapidly developing field of materials science.

Social competence

- FAMS_2K01: The student is ready to critically evaluate their knowledge and perceived content in the field of materials science, recognising the importance of knowledge in solving cognitive and practical problems.

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2.1.5. Thematic Block 5: Computational Methods and Their Applications in Materials Science

The thematic block 'Computational Methods and Their Applications in Materials Science' aims to comprehensively prepare students for the effective use of modern information and communication technologies and advanced computer methods and techniques, including computer-aided design and engineering, in research work and their future careers. The block focuses on four key aspects: introducing students to basic and advanced computational methods used in materials science, developing practical skills in the use of computer simulation tools and software, applying computational techniques to solve real-world engineering problems, and promoting an interdisciplinary approach to research and development of innovative materials through the integration of theoretical, experimental and computational methods. The flexible, modular structure of the block allows the learning path to be individually tailored to the student's personal research interests and career plans. The skills acquired will enable students to make effective use of computer and computational tools to optimise materials design, manufacturing and research processes. The programme emphasises building an understanding of the key role of advanced computational methods and computer simulations in the development of new materials and the improvement of technological processes. This awareness will enable them to see the relevance of their work in the context of global trends and challenges facing the materials industry, and motivate them to continuously develop their skills and seek innovative solutions. The programme emphasises the practical application of the knowledge gained, so that students will be well prepared to work both in modern research laboratories and in the rapidly growing industry, where skills related to computer modelling and simulation are increasingly in demand. The thematic block 'Computational Methods and Their Applications in Materials Science' aims to educate a new generation of engineers who will be able to meet the challenges posed by rapidly evolving technologies and the growing demands of the labour market.

Knowledge

- CMAME_0W01: The student has advanced knowledge of modern information and communication technologies and advanced computational methods and techniques used in materials engineering.
- CMAME_0W02: The student has a structured and theoretically underpinned knowledge of an interdisciplinary approach to materials research, integrating theoretical, experimental and computational methods.

- CMAME_0W03: The student understands the key role of advanced computational methods and computer simulations in the development of new materials and process improvements in the context of global industry trends and challenges.

Skills

- CMAME_1U01: The student is able to effectively use modern information and communication technologies and advanced computer methods and techniques to solve real engineering problems in the area of materials engineering.
- CMAME_1U02: The student is able to integrate knowledge from different disciplines and apply an interdisciplinary approach to research and development of innovative materials, combining theoretical, experimental and computational methods.
- CMAME_1U03: The student is able to independently plan and implement the continuous development of his/her skills in computational methods, taking into account rapidly evolving technologies and the increasing demands of the labour market.

Social competences

- CMAME_2K01: The student is prepared to critically evaluate his/her knowledge and skills in computational methods used in materials science and to continuously seek innovative solutions.
- CMAME_2K02: The student is ready to take on professional challenges in modern research laboratories and dynamic industry, using skills related to computer modelling and simulation.

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2.1.6. Thematic Block 6: Materials Testing Methods and Failure Analysis

The Materials Testing Methods and Failure Analysis thematic block offers students an innovative and comprehensive approach to understanding and optimising the life cycle of engineering materials, focusing on their durability and environmental impact. The programme combines advanced theoretical knowledge with practical skills, preparing students to solve complex problems related to the reliability and degradation of materials in a variety of applications. Depending on the modules chosen, students can focus on specialised areas, such as the degradation of different types of materials, and deepen their knowledge of selected research techniques. The interdisciplinary approach provides an understanding of the complex relationships between the structure, properties and functionality of materials and their behaviour in service. Participants in the programme learn to interpret research results, use them to optimise engineering designs and predict and prevent failures. In addition, they gain skills in assessing and improving the reliability of material systems, taking into account economic and environmental aspects. Upon completion of the block, graduates are well prepared to address challenges in materials engineering, with a particular focus on reliability analysis, materials life cycle assessment and the development of sustainable technologies. The programme trains professionals capable of critically evaluating and optimising the properties of materials, which is crucial for innovation in various industrial sectors and technological progress.

Knowledge

- MTMFA_0W01: Has advanced knowledge of engineering materials and their degradation mechanisms under different operating conditions.
- MTMFA_0W02: Understands the complex relationships between the structure, properties and functionality of materials and their behaviour under operating conditions and degradation processes.
- MTMFA_0W03: Has an in-depth knowledge of the environmental impact of material degradation processes and of methods for assessing the life cycle of materials in the context of sustainable development.

Skills

- MTMFA_1U01: Can select and apply advanced testing methods to analyse the properties and degradation of materials, interpreting the results obtained in the context of specific engineering applications.

- MTMFA_1U02: Knows how to carry out a comprehensive materials failure analysis, identify causes of degradation and propose preventive and optimisation solutions.
- MTMFA_1U03: Can effectively communicate the results of research and analysis of materials degradation to different audiences, including specialists from other disciplines, using specialised terminology.
- MTMFA_1U04: Is ready to plan and carry out complex research projects related to the assessment of durability and reliability of materials, taking into account technical, economic and environmental aspects.

Social competences

- MTMFA_2K01: Is prepared to critically evaluate the results of material tests and degradation analyses, and to seek expert advice when having difficulty solving a problem independently.
- MTMFA_2K02: Is prepared to initiate and implement actions to improve the durability and reliability of materials, taking into account their impact on the environment and society.
- MTMFA_2K03: Is prepared to fulfil the professional role of a materials engineer in a responsible manner, with particular reference to professional ethics in the context of materials degradation testing and analysis.

2.1.7. Thematic Block 7: Materials and Manufacturing Technology

The subject block 'Materials and Manufacturing Technologies' offers students a choice of subjects related to advanced manufacturing and materials processing techniques. The individual choice of subjects allows students to personalise their learning path to suit their own interests. Students will gain knowledge of the properties and applications of different groups of materials, such as metals, ceramics, polymers and composites, as well as the latest trends in their manufacturing technologies, such as 3D printing, powder metallurgy, sintering and casting technologies. This flexibility enables students to deepen their knowledge and skills in their chosen areas, while providing exposure to a broad spectrum of issues related to materials and manufacturing technologies.

Within the subject block, students will develop the ability to select appropriate materials and manufacturing processes for specific applications, as well as the ability to analyse and optimise manufacturing processes in terms of quality, productivity and cost. They will be able to communicate effectively with engineers from different disciplines in interdisciplinary teams. Students will also gain the ability to critically analyse and interpret experimental data.

With the skills acquired, students will be able to look at manufacturing technologies from different perspectives, taking into account technological, material, economic, environmental and social aspects. This multi-faceted approach will enable them to understand and analyse manufacturing processes in depth. One of the key elements of this approach is the development of environmental awareness in the context of material selection and manufacturing processes. Students will learn to analyse and evaluate the environmental impact of different materials and production technologies, taking into account the entire life cycle of products, from raw material sourcing to processing and waste disposal. The knowledge gained will enable them to make informed and responsible decisions that contribute to minimising the negative impact on the environment.

As a result, students will be better prepared to implement and promote sustainable practices in various industrial sectors and other areas of the economy. They will be able to identify areas where changes can be made that lead to greener solutions, and propose innovative production methods that are environmentally friendly.

Students will be prepared to take responsibility for projects and decisions related to the choice of materials and manufacturing processes and adapt to changing market requirements and new industry trends.

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Knowledge

- MM_0W01: The student has an in-depth knowledge of advanced manufacturing and materials processing techniques, including the latest technological trends in the chosen area of specialisation.
- MM_0W02: The student has an extended knowledge of the properties and applications of different groups of materials (metals, ceramics, polymers, composites) in the context of modern technologies for their manufacture.
- MM_0W03: The student understands the complex interrelationship between the choice of materials and manufacturing technology and the economic, environmental and social aspects throughout the product life cycle.

Skills

- MM_1U01: The student is able to carry out advanced analysis and optimisation of manufacturing processes in terms of quality, productivity and costs, taking into account technological and material aspects.
- MM_1U02: The student is able to communicate and collaborate effectively in interdisciplinary teams, combining specialist knowledge of manufacturing technology with knowledge from other areas of science and technology.
- MM_1U03: The student is able to critically analyse and interpret experimental data related to manufacturing processes and material properties, formulating conclusions and recommendations on their basis.

Social competences

- MM_2K01: The student is ready to plan and implement complex projects related to the selection of materials and manufacturing technologies, taking into account technical, economic and environmental aspects.
- MM_2K02: The student is ready to initiate and implement sustainable development practices in the field of manufacturing technology, promoting environmentally friendly solutions.
- MM_2K03: The student is prepared to make responsible professional decisions related to the choice of materials and manufacturing processes, taking into account their impact on society and the environment.
- MM_2K04: The student is ready to continuously monitor and adapt to new trends in manufacturing technologies, critically assessing their potential and limitations.

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2.1.8. Thematic Block 8 : Applied Materials Science

The Applied Materials Engineering thematic block aims to comprehensively prepare students for the effective use and implementation of advanced engineering materials in an industrial context. The programme combines advanced theoretical knowledge with practical engineering skills, enabling students to understand and solve the complex challenges of implementing innovative materials in different sectors of the economy. Students will explore the latest developments in materials engineering, learning about the properties, synthesis methods and potential applications of advanced materials. They will learn techniques for the design, characterisation and optimisation of materials for specific industrial applications. Depending on the chosen specialisation track, students will explore the potential of innovative materials in solving diverse global challenges, such as energy storage, water purification. This personalisation of the programme will allow students to gain a deeper understanding of the specific challenges and opportunities in their chosen area, while maintaining a solid foundation of general materials engineering knowledge. The programme also places a strong emphasis on developing a critical perspective on materials innovation. Students learn to evaluate not only the potential benefits, but also the long-term consequences and potential risks associated with the implementation of new materials. This critical perspective includes product life-cycle analysis, environmental impact assessment, ethical considerations and the social implications of using advanced materials. As a result, graduates will be able to make informed and responsible decisions that take into account the wider technological, environmental and social context. By combining advanced theory with practical projects and case studies, the 'Applied Materials Engineering' block will equip students with the comprehensive skills necessary to design, implement and optimise innovative materials solutions in modern industry. Students will be prepared to tackle complex engineering challenges, combining innovation with practical application in the evolving world of materials technology.

Knowledge

- AMSE_0W01: The student will understand the relationships between the structure and properties of engineering materials and be able to explain their importance in the context of material optimisation and selection for different industrial applications.
- AMSE_0W02: The student knows and understands the key challenges and constraints of implementing innovative materials in specific applications, including technological, economic and environmental aspects.

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- AMSE_0W03: The student understands the complex relationships between the selection of engineering materials and their functionality, durability and environmental impact during the product life cycle.
- AMSE_0W04: The student has an extended knowledge of development trends and new developments in the field of applied engineering materials and their potential impact on solving global civilisation challenges.

Skills

- AMSE_1U01: Students will be able to solve complex engineering problems related to the selection and application of engineering materials, taking into account their properties, operating conditions and economic and environmental aspects.
- AMSE_1U02: Students will be able to design and carry out complex experiments or computer simulations related to the study of the properties of engineering materials, and critically analyse and interpret the results obtained in the context of specific applications.
- AMSE_1U03: The student is able to communicate with specialists from different fields in order to effectively implement innovative materials in industrial practice, and to present and justify their decisions.
- AMSE_1U04: The student is able to explain complex issues concerning the use of engineering materials in industry to different audiences and relate them to the dilemmas of civilisation.
- AMSE_1U05: Be able to plan and collaborate in a team to carry out engineering projects related to the selection and application of innovative materials, taking on different roles within the team and demonstrating entrepreneurial skills.

Social competences

- AMSE_2K01: The student demonstrates the ability to objectively assess his/her own knowledge of the application of engineering materials, is open to new information and is prepared to consult experts to solve complex problems in the field.
- AMSE_2K02: The student is aware of his/her social role and actively engages in activities promoting innovative material solutions, aiming to have a positive impact on the environment and society.

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2.1.9. Thematic Block 10: Professional Practice

Professional Practice are a compulsory part of the study programme, during which students have the opportunity to apply the theoretical knowledge gained in academic classes to practical industrial conditions. Internships can take place in companies and institutions related to materials engineering in the broadest sense, such as production plants, research and development laboratories, design companies and research centres. During the internship, students participate in real-life tasks and projects, covering, depending on the specifics of the internship site: production technologies, materials testing, quality control, materials design or other areas specific to the organisation. An important aspect of the internship is learning about the company's organisational culture and the principles of operating in a business environment. Students learn to navigate company structures, learn about safety procedures and industry standards. Internships also provide an excellent opportunity to develop interpersonal skills - from effective team communication to professional relationships with superiors and customers. The internship programme encourages critical thinking, analysing technical problems and finding innovative solutions. Students have the opportunity to participate in research and development activities, learning about the latest trends in materials engineering and related technologies. The implementation of internships in a real industrial environment also allows for a better understanding of professional responsibility - both technically and ethically. Students learn the importance of protecting intellectual property, confidentiality rules and the impact of engineering decisions on the environment and society.

Knowledge

- PP_0W01 (P7S_WG): Has a structured knowledge of the organisational structure, management processes and functioning of the enterprise or institution in which they are undertaking their placement
- PP_0W02 (P7S_WG): Has an in-depth knowledge of specialised materials engineering issues related to the department in which the apprenticeship takes place, covering, depending on the specific location of the apprenticeship: production technologies, materials testing, quality control, materials design or other areas specific to the organisation
- PP_0W03 (P7S_WK): Knows and understands the economic, legal and ethical conditions of activity in the organisation in which he/she is practising, including the principles of safety at work, protection of intellectual property and business confidentiality

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Skills

- PP_1U01: Be able to apply knowledge of materials engineering in practice, solving real-world problems and carrying out engineering tasks in the department in which they are practising
- PP_1U02: Can critically analyse existing technical solutions used in the organisation and propose improvements or innovations, taking into account technological, economic and environmental aspects
- PP_1U03: Communicates effectively with the team, supervisors and stakeholders, presenting the results of his/her work and proposed solutions in a way that can be understood by audiences with different levels of technical knowledge
- PP_1U04: Be able to plan and carry out engineering tasks individually and as part of a team, taking on different roles within the team and demonstrating adaptability to changing conditions
- PP_1U05: Can independently plan and implement their own lifelong learning, including keeping up to date with the latest developments related to materials engineering and developing their professional competence

Social competences

- PP_2K01: Critically analyses the knowledge he/she possesses in the context of his/her tasks and responsibilities, showing a willingness to consult experts in the field when he/she encounters difficulties or doubts
- PP_2K02: Develops his/her professional competence by independently expanding his/her knowledge and skills, keeping abreast of the latest trends in materials engineering and related fields
- PP_2K03: Is aware of the social responsibility associated with the performance of assigned tasks and demonstrates a willingness to initiate actions in the public interest
- PP_2K04: Observes the principles of professional ethics and cares for the development of his/her profession, taking into account changing social and technological conditions

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2.1.10. Thematic Block 11: Research project - Master's thesis

The thematic block 'Research Project - Master Thesis' is a comprehensive module that prepares the student to conduct research independently and to write a master's thesis. The aim of this block is to equip the student with the necessary knowledge, skills and competences to successfully complete a research project, from the formulation of the research problem to the presentation and defence of the results.

Within this block, the student acquires an in-depth knowledge of research methodology, specific to the scientific field related to the topic of the thesis. He or she learns how to properly plan and conduct research, selecting appropriate research methods and tools. An important element is also the acquisition of the ability to critically analyse and interpret the results, as well as to present them in written and oral form, using specialised terminology.

The subject block places a strong emphasis on developing the student's independence and creativity in the research process. The student learns how to search and select scientific information effectively, using a variety of sources such as databases, scientific journals and conference materials. He or she also acquires knowledge of the standards for the preparation of a master's thesis, taking care of its appropriate structure, the presentation of results and the correctness of citations and bibliography.

An important aspect of this block is the formation of soft competences such as time and resource management, critical self-assessment, entrepreneurial thinking or adherence to ethics in research. Students also learn how to use artificial intelligence tools responsibly and ethically in the process of preparing their thesis, respecting the principles of academic integrity.

Developing the skills of scientific discussion, formulating arguments and counter-arguments and defending one's own position is also an important element of the block. The student learns how to use knowledge from the fields of science and scientific disciplines relevant to the topic of the master's thesis in progress in order to effectively present and defend his/her arguments.

Knowledge

- RPMT_0W01: The student knows and understands the principles of planning and conducting scientific research, including the formulation of research hypotheses, the selection of research methods and tools and the interpretation of results.
- RPMT_0W02: The student knows and understands advanced research methods and techniques specific to the field of study related to the thesis topic.

- RPMT_0W03: The student knows and understands the principles of presenting research findings that are scientific in nature, in the context of preparing a thesis.
- RPMT_1U01: The student is able to independently plan and carry out scientific research related to the topic of the thesis, selecting appropriate methods and tools.
- RPMT_1U02: The student is able to critically analyse and interpret research results, formulate conclusions and identify limitations of the research methods used.

Skills

- RPMT_1U03: The student is able to present research findings in written and oral form, using specialised terminology and adapting the form of communication to the audience.
- RPMT_1U04: The student is able to effectively search, select and use scientific information necessary for research using a variety of sources such as databases, scientific journals and conference proceedings.
- RPMT_1U05: The student is able to prepare a master's thesis according to accepted standards, taking care of its proper structure, division into chapters, the manner of presenting research results and the correctness of citations and bibliography.

Social competences

- RPMT_2K01: The student is prepared to manage time and resources responsibly when carrying out scientific research, demonstrating self-discipline, punctuality and attention to completing scheduled tasks on time.
- RPMT_2K02: The student is ready to critically evaluate his/her own knowledge and skills and recognise the importance of expert knowledge in solving research problems.
- RPMT_2K03: The student is prepared to think and act in an entrepreneurial manner, seeking innovative solutions to research problems.
- RPMT_2K04: The student is prepared to observe the principles of ethics in research and the protection of intellectual property.
- RPMT_2K05: The student is ready to use artificial intelligence (AI) tools responsibly and ethically in the process of preparing the thesis, respecting the principles of academic integrity and taking into account the limitations of these tools.
- RPMT_2K06: The student is ready to conduct a scientific discussion, including the formulation of arguments, counter-arguments and the defence of his/her own position, using the knowledge of the fields of science and scientific disciplines relevant to the topic of the completed thesis.

2.1.11. Thematic Block 12: Humanities and Social Science Block

The general humanistic module allows the student to become acquainted with selected areas of the subject specificity of the humanities. The student has a chance to compare various methodological and interpretative approaches, acquires knowledge about the benefits of adopting a humanistic perspective on reality. The student learns to implement the recognised paradigms of humanistic thinking in his/her scientific activity, creatively solving the problems posed in class. On specific cases, he/she develops the ability to integrate approaches characteristic of the humanities with viewpoints belonging to the fields of science and scientific disciplines relevant to the studied major. In the course of his/her encounters, he/she identifies paths of participation in current and future cultural formations, recognizing in the presented and experienced activities the paths of individual participation in the life of human communities proper to him/her.

- HMO1_1: The student knows selected issues concerning the subject specificity of the humanities, understands their nature, place and significance in the system of sciences, as well as their connections with the fields of science and scientific disciplines appropriate to the studied major, allowing the student to integrate perspectives appropriate to different scientific disciplines.
- HMO1_2: The student is able to select, interpret and evaluate knowledge from selected disciplines in the humanities and to integrate and apply it in scholarly activity and professional practice in a way that enables original and creative solutions to problems experienced as a cultural participant.
- HMO1_3: The student is able to creatively undertake, analyse and contribute to current socio-cultural discourses, using knowledge of the studied problems of contemporary humanities and acquired communication skills and substantive argumentation taking into account different scientific approaches and types of scientific reflection.
- HMO1_4: The student, being a participant in cultural life, in its various manifestations, demonstrates the need for continuous learning and improvement of those dispositions that allow one to appreciate humanistic reflection and to integrate it with issues and experiences resulting from the choice of one's own path of academic and professional activity, as well as those related to individual cultural activity.

The general social science module allows the student to become acquainted with selected areas of the subject-specific social sciences. The student has the opportunity to compare various methodological and interpretative approaches, acquires knowledge of the benefits of adopting a perspective characteristic of the social sciences to view reality. On the basis of specific cases, he/she develops the ability to integrate approaches characteristic of the social sciences with viewpoints belonging to the fields of science and scientific disciplines relevant to the studied major.

- SMO1_1: The student knows selected issues concerning the subject specificity of social sciences, understands their nature, place and importance in the system of sciences, as well as their connections with the fields of science and scientific disciplines appropriate for the studied major, allowing the student to integrate perspectives appropriate for various scientific disciplines.
- SMO1_2: The learner is able to select, interpret and evaluate knowledge from selected disciplines in the social sciences and integrate and apply it in scholarly activity and professional practice in a way that enables original and creative solutions to problems experienced as a participant in social life.
- SMO1_3: The student is able to creatively undertake, analyse and contribute to current socio-cultural discourses, using knowledge of the studied content, acquired communication skills and substantive argumentation taking into account different scientific approaches and types of scientific reflection.
- SMO1_4: The student, being a participant of social life, in its various manifestations, demonstrates the need for continuous learning and improvement of those dispositions which result from the choice of his/her own path of scientific and professional activity and also related to individual social activity.

2.2. The Role of the Learning Outcomes Defined for the Thematic Blocks and the Responsibility of the Trainers

The learning outcomes assigned to individual subject blocks form the foundation of the study programme, precisely defining the knowledge, skills and social competences a student should acquire after passing the subjects included in a given block. They determine the direction and scope of education, ensuring the coherence and complementarity of the content taught in the various subjects. The learning outcomes defined for each subject block were carefully cross-referenced to the learning outcomes defined for the whole programme. The aim of this process was to ensure that all the intended learning outcomes defined for the course of study are fully realised through the achievement of the outcomes assigned to the individual subject blocks.

Course instructors play a key role in achieving the outcomes of a particular subject block. Their task is to plan and conduct the teaching process in a way that enables students to achieve the expected learning outcomes. To this end, instructors should:

- Thoroughly familiarise themselves with the learning outcomes assigned to the thematic block within which they teach.
- Select the content, teaching methods and forms of verification of achieved results in a way that serves the achievement of the modular effects.
- Treat the realisation of the module outcomes as a priority when planning and teaching.
- Liaise with the subject block coordinator and other tutors to ensure consistency and complementarity of the teaching process.

Instructors should be aware that any modifications to the content or forms of teaching should be made with a view to their impact on the possibility of achieving the intended learning outcomes. In case of difficulties or doubts concerning the achievement of the outcomes, instructors should consult with the block coordinator in order to work out optimal solutions.

The coordinators of the individual subject blocks have a supervisory and supportive role in the implementation of the modular effects. Their tasks include:

- Monitor the delivery of learning outcomes within the block and ensure consistency of the teaching process.
- Support instructors in the planning and delivery of activities in line with the intended outcomes.
- Providing advice and assistance if difficulties or concerns arise in the implementation of the outcomes.
- Initiate and moderate collaboration between instructors to optimise the teaching process.

- Carry out periodic reviews and evaluations of the implementation of module outcomes and initiate corrective action where necessary.

The subject block coordinators are responsible for ensuring the high quality of education and the achievement of the assumed learning outcomes. Their active attitude and involvement in the didactic process are essential for the success of the study programme and the achievement of the assumed competences by the students.

The realisation of the learning outcomes defined for the thematic blocks requires close cooperation and effective communication between all members of the teaching team, including lecturers and block coordinators. Regular meetings, exchange of experiences and joint search for optimal teaching solutions should be an integral part of the learning process.

Through openness to dialogue and readiness to collaborate, the teaching team will be able to effectively implement learning outcomes, respond to emerging challenges and provide students with high quality education. Only through the synergy of activities and the involvement of all those responsible for the teaching process is it possible to achieve the desired results.

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3. Teaching Methods in Materials Science Ma(s)ters Study Program

3.1. Introduction

In the rapidly evolving field of materials science and engineering, effective teaching methods are crucial to equipping students with the knowledge and skills required to thrive in both academic and professional environments. Strong Materials Science education is essential for quality part development and efficient designs. Comfort, safety, and cost requirements can be met using technology and knowledge base advancements. Successful Materials Science education helps technological development and increases innovations.

The effective teaching methods explore various pedagogical approaches emphasizing their application in materials engineering education. By integrating traditional and innovative teaching strategies, educators can enhance student engagement, deepen understanding, and foster the practical competencies essential for materials scientists and engineers.

Materials engineering, with its blend of theoretical principles and practical applications, demands a multifaceted approach to teaching. Effective materials engineering education should not only convey scientific and technical knowledge but also develop problem-solving abilities, creativity, and an understanding of real-world engineering practices. Materials engineering courses should balance theoretical instruction with practical applications. For example, a course on materials characterization might combine lectures on analytical techniques with laboratory sessions where students use instruments such as scanning electron microscopes (SEMs) or X-ray diffraction (XRD) equipment.

Using case studies drawn from industry can help students understand the relevance of their learning. For instance, examining the materials selection process in the design of a new aerospace component can illustrate the interplay between material properties, processing techniques, and performance requirements.

Group projects that simulate real-world engineering tasks can develop teamwork and project management skills. In a materials engineering context, students might work together to design and prototype a new composite material, considering factors such as material selection, manufacturing processes, and testing protocols. Research-Based Learning: Encouraging students to engage in research projects can deepen their understanding and foster innovation. This might involve investigating new materials, exploring novel applications, or conducting experiments to validate theoretical models.

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Collaborations with industry can provide students with valuable insights and practical experience. Internships, co-op programs, and guest lectures from industry professionals can bridge the gap between academic learning and professional practice.

Incorporating computational tools and simulations into the curriculum can help students visualize complex phenomena and perform virtual experiments. Software for materials modelling, such as finite element analysis (FEA) or molecular dynamics (MD) simulations, can enhance learning and research capabilities.

3.2. Overview of Teaching Methods in Higher Education generally and in Materials Science

Teaching methods in higher education encompass a wide range of strategies designed to facilitate learning and promote critical thinking. These methods can be categorized into several types explained in detail in the following text.

3.3. Assimilation Teaching Methods

Assimilation teaching methods focus on helping students integrate new information into their existing cognitive structures, facilitating a deeper understanding and retention of knowledge. This approach is rooted in cognitive learning theories, particularly those proposed by Jean Piaget, which emphasize the processes of assimilation and accommodation in cognitive development.

Assimilation involves incorporating new information into pre-existing schemas (mental models or frameworks). When students encounter new concepts, they interpret and understand these concepts based on their prior knowledge and experiences. Assimilation teaching methods aim to make this process as seamless as possible by building on what students already know and guiding them to connect new information with their existing cognitive frameworks.

Assimilation teaching methods are useful in building on prior knowledge. Effective assimilation teaching starts by assessing students' existing knowledge and understanding. Educators can use diagnostic assessments, pre-tests, or informal questioning to gauge what students already know about a topic. This helps in designing instruction that links new content to familiar concepts.

Assimilation methods often involve breaking down complex information into smaller, manageable pieces. This allows students to gradually build on their knowledge, assimilating new information step-by-step without becoming overwhelmed.

An important feature of assimilation teaching is scaffolding, which involves providing temporary support to students as they learn new concepts. This can include hints, cues, prompts, and guided practice. As students become more proficient, these supports are gradually removed, encouraging independent learning and assimilation.

Analogies and examples used in assimilation teaching can bridge the gap between new and existing knowledge. By relating unfamiliar concepts to familiar ones, educators can help students see the connections and assimilate new information more effectively. For instance, explaining electrical conductivity in metals by comparing it to water flowing through pipes can make the concept more relatable. Encouraging active engagement with the material helps reinforce assimilation. Activities such as discussions, problem-solving tasks, and hands-on experiments require students to actively process and integrate new information into their existing knowledge base.

Providing timely feedback and opportunities for reflection is crucial in the assimilation process. Feedback helps students correct misconceptions and refine their understanding, while reflection encourages them to think about how new information fits with what they already know.

An overview of assimilation teaching methods is presented in Tab 1.

Table. 1 Overview of assimilation teaching methods

Method	Description
Informative lecture	Traditional lectures involve the instructor delivering content directly to students. This method is effective for disseminating large amounts of information and providing expert insights into complex topics. In materials engineering, lectures can cover theoretical concepts, historical developments, and foundational knowledge.
Monographic lecture	An exhaustive presentation of one topic is usually related to the research problem of the lecturer or a detailed presentation of one selected topic.
Description	Description of objects, phenomena, processes, or people; involves determining the structure and characteristics of the described phenomenon, object, or process; the description is usually accompanied by a demonstration of the described object or

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	its models, drawings, tables, charts, etc.; the description may take the form of explanation, classification, justification or comparison.
Reading	A variant of lecture: a way of referring to content prepared in written form; a lecture may be given by the lecturer or a guest.

Application of assimilation methods in materials engineering

In the context of materials engineering, assimilation teaching methods can be particularly effective due to the interdisciplinary nature of the field, which often requires integrating knowledge from physics, chemistry, and engineering.

An important approach is connecting theory to practice. To facilitate assimilation, educators can connect theoretical concepts to practical applications in materials engineering. For example, when teaching about crystallography, instructors can link the atomic structure of materials to their macroscopic properties, such as strength and ductility, and then discuss real-world applications like the design of aerospace components. Designing the curriculum in sequential modules that build on each other can aid assimilation. A course might start with basic concepts like atomic structure and bonding, then move on to more complex topics like phase diagrams and material properties, ensuring that each new topic builds on the previous ones. Hands-on laboratory experiments and computer simulations can help students assimilate theoretical knowledge by seeing it in action. For example, an experiment demonstrating the tensile strength of different materials can help students understand the underlying principles of stress and strain.

Projects that require knowledge integration from multiple disciplines can promote assimilation. A project that involves designing a new composite material might require students to apply concepts from chemistry (polymer chemistry), physics (mechanical properties), and engineering (manufacturing processes).

Regular assessments and constructive feedback are essential to ensure students are assimilating the material correctly. Quizzes, group discussions, and one-on-one meetings can provide insights into students' understanding and areas that need reinforcement.

Assimilation teaching methods are a powerful approach in education, focusing on integrating new knowledge with existing cognitive structures. By building on prior knowledge, providing scaffolding, using analogies, encouraging active engagement, and offering feedback, educators can enhance students' understanding and retention of complex concepts. In materials engineering, these methods can bridge the gap between theoretical knowledge and practical application, preparing students for successful careers in this dynamic field.

3.4. Problem-based Teaching Methods

Problem-based teaching methods are an educational approach centred around engaging students in solving real-world problems. This method encourages active learning, critical thinking, and the application of knowledge across various disciplines. Originating from medical education, problem-based learning (PBL) has been adapted across many fields, including materials science and engineering, to promote a deeper understanding and practical application of theoretical concepts.

In PBL, students take the lead in their learning process. They are presented with a problem and must identify what they need to learn to solve it. This shifts the role of the teacher from information provider to facilitator and guide. The problems used in PBL are often complex, open-ended, and reflective of real-world situations. This relevance motivates students and helps them see the practical applications of their studies. PBL typically involves collaborative group work. Students work in teams to discuss the problem, share knowledge, and develop solutions. This collaboration fosters communication, teamwork, and the exchange of diverse perspectives. Students identify their learning needs and seek out resources independently. This self-directed approach helps develop lifelong learning skills, such as research, time management, and self-assessment.

PBL encourages the integration of knowledge from different subjects and disciplines. For example, in materials engineering, solving a problem might require understanding concepts from chemistry, physics, and mechanical engineering. Reflection is a critical component of PBL. Students are encouraged to reflect on their learning process, the effectiveness of their solutions, and what they could improve in future problem-solving efforts.

Problems in PBL should be carefully designed to be challenging yet achievable. They should be relevant to the student's future professional practice and require the application of interdisciplinary knowledge. Instructors act as facilitators, guiding students through the problem-solving process without providing direct answers. They ask probing questions, provide resources, and help students stay on track. Effective group work is essential in PBL. Instructors may need to teach students how to work effectively in teams, resolve conflicts, and make decisions collaboratively.

In PBL, students should have access to various resources, such as textbooks, research articles, online databases, and laboratory equipment. Instructors may provide initial resources and guide students on how to find additional information.

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Assessment in PBL focuses on both the process and the product of learning. This can include self-assessment, peer assessment, and instructor evaluation. Criteria may include the quality of the solution, the problem-solving process, teamwork, and individual contributions.

PBL has numerous benefits for students. It develops students' critical thinking and problem-solving skills as they analyze complex problems and devise solutions. By engaging with real-world problems, students achieve a deeper understanding of the subject matter, going beyond rote memorization to apply concepts in practical contexts. PBL emphasizes teamwork and communication, essential skills in professional engineering practice. It also promotes self-directed learning, helping students become independent learners capable of continuously updating their knowledge and skills.

An overview of problem-based teaching methods is listed in Tab 2.

Table. 2 Overview of problem-based teaching methods

Method	Description
Problem-based lecture	An analysis of a selected scientific or practical problem with verification an attempt to solve the raised issue, and an indication of the consequences of this solution.
Conversational lecture	Delivered content that considers the interaction with the lecture's audience; discussion related to the lecture is one of its elements or its continuation.
Activating methods:	
Didactic games	Learning content included in the formula of a game with rules, principles and regulations; conducted in a purposefully organised situation based on the description of facts and processes, learners compete with each other within the framework of rules determined by the academic teacher; simulation games - involve simulating real situations; decision-making games - are based on the process of decision-making with knowledge of their consequences (e.g. decision tree), psychological games - require the participation of the emotional-volitional component of the attitude.

Discussion/Debate	Exchange of views with the use of substantive arguments, as a result of which different views clash, compromises are worked out, and common positions are defined; the discussion is conducted based on the rules previously agreed with the group: including those regarding the time, method and order of presenting points of view and the rules of polite discussion; the discussion is aimed at finding the best solutions, presenting different points of view, it is not a competition; a debate is an orderly dispute between supporters and opponents of a statement, usually conducted by specialists in the field or pre-selected representatives of a group dealing with a common problem. Types of discussion: brainstorming, oxford debate, panel discussion, decision tree, conference discussion.
Seminar/Proseminar	Usually a verbal presentation of a previously developed/diagnosed problem on the forum to provoke a discussion around the results of research work; a type of conference, course, or training modelled in the form of seminar classes.
Staging/Drama	Experiential learning; solving a problem by acting in a role; otherwise; role method; role-players interpret it individually; activation of the senses, imagination, speech, stimulation of gesture and movement, etc., serve to identify with the played role; the purpose of drama is mediated by the role of experiencing specific situations, problems, and events. Staging is a method of roles enriched with props and scenography illustrating the theme.
Case study	A comprehensive description of the phenomenon related to the selected discipline; reflecting reality, presenting the specificity of the phenomenon with all its essential aspects to be discussed during the classes (what? where? how?); used as a reproduction, presentation, discussion, diagnosis of factors that shape

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	the phenomenon or interact with it; in-depth qualitative analysis and evaluation of a selected phenomenon.
Peer learning	Learning through the exchange of knowledge in a group/team/couple, i.e. teaching cell; a kind of mutual learning; an approach focused on student activity with the accompaniment of an academic teacher conducting classes; teaching where students with a similar level of experience learn from each other.
Flipped classroom	Anticipatory learning; work in class is based on previously studied material indicated by the teacher; preparation out of classes is used to learn about the issues that are a condition for participating in the discussion and to practice related practical skills; the activity load is based on the student's work with the teacher's accompaniment. Students are introduced to content before class through readings or videos, and class time is dedicated to interactive activities and deeper exploration of the material. This approach can enhance understanding and retention by allowing students to engage with the content at their own pace and participate actively during class.
Other methods:	
SWOT analysis	Method of analysing the phenomenon/action/work of an institution to organize information and solve problematic issues; used in the strategic planning, project implementation or solving a business/organizational problem; a universal tool for the initial stage of strategic analysis consisting in sorting information about the issue within four categories: strengths and weaknesses, opportunities and threats; SWOT analysis makes it possible to determine the chances of a project's success and its strengths, as well as to eliminate or reduce weaknesses and threats to project implementation at the early diagnosis stage.
Exposure	Preparing and displaying the object for public display to provoke an appropriate reaction; creating a thematic collection of specimens/objects/works to illustrate a specific issue.

Projection	Reproduction of the film material (video/film) in its entirety or fragments as an element of illustration of the content taught as part of the classes, the subject of analysis and evaluation of the work or an exercise method of image perception; film/video is a work/artistic work, illustration including technical content/phenomena/object, a private record of action, media image, etc.
Audio playback/Playback	Preparation and reproduction of sound material (audio recording) in whole or in part, as an element of illustration of the content, taught during classes, or the subject of analysis and evaluation of a work, or a method of sound perception, including a musical piece, an artistic radio drama, an artistic, media or scientific text read; analysis of the sound material recorded on the carrier to analyse the sound-related phenomenon.
Poster	Graphical vision of presenting the problem and the possibility of solving it in the form of a board: a one-piece or a collection of several elements included in a coherent graphic form.
Show/Demonstration	Exemplary presentation of how to perform specific activities with an overview; the aim is to trigger imitation activities individually or in a group of participants observing the activities of the person conducting the classes until the proper habit is formed through regular exercise; the demonstration method is combined with a practical discussion of activities/behaviours.
Presentation	Mechanical presentation of a synthetic image of content in the form of presentation graphics, e.g. a series of slides or other multimedia formats, usually with a discussion/additional commentary; typical components of the presentation - text enclosed in points, chart, graphics (images) and animations; any sound effects or music; multimedia illustration content of classes presented in the form of a projected image.

Application of problem-based teaching methods in materials engineering

In materials engineering, PBL can be particularly effective due to the field's reliance on solving complex, real-world problems. The examples of specific applications of PBL in materials engineering can be:

- Materials Selection and Design: Students may be given a problem where they need to select the appropriate material for a specific engineering application, such as designing a lightweight, high-strength component for an aerospace application. They would need to consider factors like material properties, cost, manufacturability, and environmental impact.
- Failure Analysis: A problem might involve analyzing the failure of a structural component. Students would investigate the failure modes, perform material testing, and recommend improvements in material selection or design to prevent future failures.
- Sustainability Challenges: Students could be tasked with developing sustainable materials or processes. This might involve researching alternative materials, assessing lifecycle impacts, and proposing innovative solutions to reduce environmental footprints.
- Innovation Projects: PBL can also drive innovation by challenging students to develop new materials with specific properties or to create novel applications for existing materials. This fosters creativity and encourages the practical application of theoretical knowledge.

Problem-based teaching methods offer a dynamic and effective approach to education, particularly in fields like materials engineering. By focusing on real-world problems, fostering collaboration, and encouraging self-directed learning, PBL helps students develop the critical thinking, problem-solving, and interdisciplinary integration skills essential for their future careers. This approach not only enhances academic learning but also prepares students to tackle the complex challenges they will face as professional engineers.

3.5. Practical Teaching Methods – Experiential Learning

Experiential learning is a practical teaching method that emphasizes learning through direct experience and reflection. It is based on the idea that knowledge is constructed through real-world, hands-on activities rather than passive reception of information. This approach is particularly effective in fields such as materials science and engineering, where understanding complex concepts and developing practical skills are crucial.

Experiential learning involves engaging students in activities that reflect real-world challenges and require active participation. The experiential learning cycle, proposed by David Kolb, outlines four key stages:

- Concrete Experience: Engaging in a hands-on activity or experience.
- Reflective Observation: Reflecting on the experience and identifying key takeaways.
- Abstract Conceptualization: Developing theories or models based on the reflection.
- Active Experimentation: Applying the new knowledge to solve problems or engage in new experiences.

This cyclical process ensures that students not only gain practical experience but also reflect on their learning, integrate new knowledge, and apply it in various contexts.

Experiential learning is based on hands-on activities - students engage in practical tasks that require them to apply theoretical knowledge. These activities can range from laboratory experiments to fieldwork and internships. Learning activities are designed to mimic real-world scenarios, making the knowledge and skills gained directly applicable to professional practice.

Reflective practice is integral to experiential learning. Students are encouraged to think critically about their experiences, receive feedback, and learn from their successes and mistakes. Students take an active role in their learning process, making decisions, solving problems, and collaborating with peers. Besides that, the experiential learning cycle promotes continuous learning through repeated engagement in activities, reflection, and application.

Experiential Learning brings numerous benefits. It helps students gain a deeper understanding of theoretical concepts by seeing them in action and applying them in practical contexts. Hands-on activities develop practical skills that are essential for professional practice, such as laboratory techniques, data analysis, problem-solving, and project management. Real-world relevance and active participation increase student engagement and motivation, making learning more enjoyable and meaningful. Reflective practice encourages students to think critically about their experiences, learn from their mistakes, and continuously improve their understanding and skills. Experiential learning also prepares students for the workforce by providing them with practical experience, industry knowledge, and the confidence to tackle real engineering challenges.

An overview of practical teaching methods is listed in Tab 3.

Table. 3 Overview of practical teaching methods

Method	Description
Laboratory Exercise/Experiment	Method of the practical application of knowledge; implemented in three phases: noticing the problem caused by the content of the task, formulating the problem and attempting to solve it independently with the assessment of the effects; the goal is to acquire skills, abilities and habits and to consolidate the acquired knowledge so that it becomes operational knowledge; the laboratory method assumes greater independence of learners than experimenting.
Production exercise - workshop	Exercises involve creating an object/product according to the rules/principles/description of an academic teacher as a master of a specific workshop.
Practice	The practice of skills in real conditions, corresponding to the subject specificity of education, e.g. in the environment, institution, or place of work in which the student is preparing as part of his studies; an exercise in real working conditions. This method includes professional and individual practice.
Observation	Method of systematic/planned perception of phenomena, objects, and people to gain knowledge about them; perceptual separation of elements of the action model as an element of learning through imitation; a complex of sensory cognition based on sensory experiences.
Simulation	The indirect method which is imitating reality to gain an experience close to the real thing; recreating the situation from reality in such a way that the experiences obtained with its help are comparable to real; work on substitute material.

Application of experiential learning in materials engineering

In materials engineering, experiential learning is vital for developing hands-on skills and understanding the practical applications of theoretical knowledge.

Labs are a cornerstone of experiential learning in materials engineering. Students conduct experiments to understand material properties, test hypotheses, and develop practical skills in using equipment and analyzing data. For example, a lab on tensile testing might involve measuring the mechanical properties of different materials and comparing the results.

In cases where physical labs are not feasible, simulations and virtual labs can provide valuable experiential learning opportunities. Software tools can simulate material behaviours, manufacturing processes, and engineering scenarios, allowing students to experiment and learn in a virtual environment.

Important parts of experiential learning in the field of materials engineering are industry internships and cooperation programs. These programs provide students with the opportunity to work in industry settings, applying their knowledge to real engineering challenges. The obtained experiences help students understand professional practices and build industry-relevant skills. Visits to industrial sites, research facilities, or engineering projects allow students to see the practical application of materials science concepts in real-world settings. These experiences can provide insights into the manufacturing processes, quality control, and applications of different materials.

Capstone projects are comprehensive assignments typically completed in the final year of a degree program. These projects require students to integrate their knowledge and skills to address a complex engineering problem, often in collaboration with industry partners.

Experiential learning is a powerful teaching method that bridges the gap between theoretical knowledge and practical application. In materials engineering, this approach is particularly valuable, as it enables students to understand complex material behaviours, develop essential practical skills, and prepare for professional careers. By engaging in hands-on activities, reflecting on their experiences, and applying their knowledge in real-world contexts, students can achieve a deeper, more integrated understanding of materials science and engineering principles.

3.6. Programming Teaching Methods

Computer and programming methods are significant in education and leverage technology to enhance learning experiences, particularly in fields like materials science and engineering. These methods involve the use of computer-based tools, software, and programming to teach concepts, simulate real-world scenarios, and solve complex problems. Integrating these methods into the curriculum can provide students with valuable skills that are highly relevant in today's technology-driven world.

Computer simulations can model complex systems and phenomena that would be difficult or impossible to observe directly. These simulations allow students to experiment with variables and see the results in real time, facilitating a deeper understanding of theoretical concepts. Teaching students to program enables them to automate tasks, analyze data, and develop custom software solutions. Programming languages commonly used in engineering, such as Python, MATLAB, and C++, are particularly valuable.

Computers can process large datasets and produce visualizations that make complex data more accessible and easier to understand. This is essential for interpreting experimental results and making informed decisions based on data. Computer-aided design (CAD) software allows students to create detailed 3D models of components and systems. This is crucial for designing, testing, and refining materials and products in a virtual environment before physical prototypes are built. Finite Element Analysis (FEA) software helps in understanding how materials and structures behave under various conditions. By simulating stress, strain, and other physical phenomena, students can predict performance and optimize designs.

Learning Management Systems platforms like Moodle and Teams provide a centralized hub for course materials, assignments, and communication. They facilitate blended learning environments where online resources complement traditional classroom activities.

The use of programming teaching methods has a lot of benefits. Interactive simulations and visualizations can make abstract concepts more concrete, improving comprehension and retention. Learning to program and use advanced software tools prepares students for the demands of modern engineering roles, where such skills are increasingly essential. Computers can process data and perform calculations much faster and more accurately than manual methods, increasing efficiency and precision in analysis and design. Students also gain experience with industry-standard tools and software, making them more competitive in the job market. Among other benefits, computer-based learning can often be accessed remotely, providing flexibility for students and increasing accessibility to educational resources.

An overview of programming teaching methods is listed in Tab 4.

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Table. 4 Overview of programming teaching methods

Method	Description
Work with computer	Webquest - the implementation of educational tasks using electronic and digital devices, computer programs and Internet applications; The academic teacher acts as a consultant; the students' work proceeds according to the plan specified by the person conducting the classes, taking into account the stages and instructions, and aims at developing the indicated results within the set deadline.
Working with the program manual	Work using a textbook structured to cover part or all of the curriculum of a module with a specific form of content study; including work with a subject textbook, atlas, catalogue, workbook, etc.
Working with another teaching tool	Using websites in any way or according to the rules set by the teacher; or others, specific to the subject of study.
Reconstruction/Restoration	proceeding according to the indicated/demonstrated pattern; e.g. reconstruction of a layout, model, image, etc.

Application of programming methods in materials engineering

Computer and programming methods are integral to modern materials science and engineering education. By incorporating these methods into the curriculum, educators can enhance student learning, develop essential technical skills, and prepare students for successful careers in a technology-driven world. From simulations and CAD to programming and data analysis, these tools provide powerful means to explore, understand, and innovate within the field of materials science.

3.7. Conclusion

Effective teaching methods in a Materials Science Master's Study Program are critical for fostering deep understanding, innovation, and practical application of complex materials science concepts. A successful program must balance theoretical instruction with hands-on laboratory experiences, project-based learning, and research-driven activities, allowing students to engage with both foundational knowledge and cutting-edge advancements in the field.

The diverse teaching methods discussed in this chapter reflect the multifaceted nature of materials science and engineering education. By leveraging a combination of traditional and innovative pedagogical approaches, educators can create a dynamic and effective learning environment. This not only enhances students' theoretical understanding but also equips them with the practical skills and critical thinking abilities essential for their future careers.

By utilizing a diverse range of teaching methods, the **Materials Science Master's Study Program** can equip students with not only the technical expertise but also the analytical, practical, and collaborative skills required to excel in both research and industry, making them capable of driving innovation in the ever-evolving field of materials science.

4. Hybrid Teaching in the Materials Science Masters Programme: Concept and Implementation

In an era of digital transformation of education, e-learning has become a common tool in higher education. However, in fields such as materials engineering, where practical experience and laboratory skills are key, a full transition to online learning can raise legitimate concerns. The Materials Science Masters (MSM) project team faced a fundamental challenge: how to harness the potential of digital technologies without losing the essence of engineering education? This question led the project team to analyse in depth the role of technology in engineering education and to critically assess the potential and limitations of e-learning in the context of the discipline of materials engineering. This reflection became the starting point for further activities and decisions. Traditional engineering studies are based on direct contact with materials, laboratory equipment and manufacturing processes. The ability to manipulate samples, operate sophisticated equipment or interpret in situ test results are competences that cannot be fully conveyed through a 'computer screen'. At the same time, the potential offered by modern educational technologies - the ability to visualise complex processes, access the latest research or the flexibility to assimilate theoretical knowledge - cannot be ignored. In the face of these challenges, blended learning appears as a promising solution, combining the best features of both worlds. It allows the necessary elements of practical learning to be retained, while at the same time exploiting the advantages of online learning. However, successful implementation of this model requires a deep understanding of the specifics of the field, the needs of the students and the technological possibilities.

4.1. Exchange of Good Practices as a Foundation for SWOT Analysis

A key element in the development of the blended learning concept for the Materials Science Masters programme was the exchange of good practice between the partner universities implementing the project. During a number of project meetings, both online and onsite, the project teams shared experiences of implementing e-learning elements at their home institutions. Particularly valuable was the experience gained during the Covid-19 pandemic, which forced universities to quickly switch to distance learning. Each university presented its successes, challenges and lessons learned from this intensive period of implementing remote learning in materials engineering. During these discussions, it was decided to take a two-pronged approach, analysing e-learning from the perspective of both students and lecturers. This provided a more complete picture, taking into account the needs, concerns and expectations of both key groups of educational stakeholders.

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The experience-sharing sessions allowed the identification of common problems, but also the discovery of unique solutions developed by individual universities. Discussions on:

- Methods of integrating online classes with laboratory practice
- Strategies for engaging students in a virtual environment
- E-learning tools and platforms best suited to teaching engineering
- Ways of overcoming academic staff resistance to new technologies

The result of this intensive exchange of experiences was the development of a comprehensive picture of the strengths and weaknesses of blended learning in the context of engineering studies. The knowledge, coming from a variety of academic backgrounds and enriched by intensive pandemic experiences, formed the basis for a SWOT analysis.

Strengths

- In the blended learning model, key practical and laboratory activities continue to take place onsite, allowing students to gain practical skills directly.
- Learning materials are available online 24/7, making it easier for students to learn on their own at a time that is convenient for them. This allows them to revisit more difficult topics and learn at their own pace, which promotes better understanding of the material.
- The use of advanced learning tools, such as simulations, 3D visualisations and instructional videos, enables a better understanding of complex processes.
- Students and lecturers develop skills in the use of modern technology, which is valuable in the labour market. The ability to use digital tools, manage time and work remotely are becoming desirable professional competences.
- Blended learning allows some classes to be taught remotely by lecturers from different parts of the world, without them having to be physically present. This enriches the curriculum with international experiences and perspectives.

Weaknesses

- Difficulties in imparting practical and laboratory skills that are crucial in materials engineering. Online teaching cannot fully replace direct contact with materials, laboratory equipment and manufacturing processes.
- Online teaching does not allow for immediate help with more difficult issues, which can affect the quality of learning.

- Reluctance of some lecturers to learn new technologies and teaching methods. Adapting to blended learning requires a change in approach, familiarity with technology and additional training, which may be met with resistance from some staff.
- The transition to a blended learning model may initially increase the workload for lecturers. The need to prepare online materials, moderate discussions and provide individual feedback can be time-consuming, especially during the implementation phase of the new system.
- The virtual environment can make it difficult to maintain a high level of engagement and interaction between students and lecturers. The lack of physical presence and face-to-face contact can affect students' motivation and the quality of their participation in class.
- Implementing a blended learning model requires significant investment in time and money, both at the training level and in the development of dedicated learning materials, which can be a major organisational challenge for universities.

Opportunities

- The continuous development of educational tools creates opportunities to introduce innovative teaching methods that can enrich students' learning experiences.
- The labour market shows a high demand for engineers with skills in new technologies, which can make students more competitive in the labour market.
- Collaboration with other blended learning universities and institutions can lead to the exchange of best practice and innovative solutions in engineering education.
- Modern and innovative teaching methods can increase interest in science and technology among young people.
- Adaptive e-learning systems can tailor content to individual students' needs and learning styles. The use of artificial intelligence in personalising learning pathways can revolutionise the way students assimilate knowledge.
- Collaborations with companies can lead to the creation of virtual laboratories and simulations based on real engineering challenges.

Threats

- If appropriate standards for the courses are not put in place, there is a risk of a reduction in the quality of blended learning.
- Failure of technology , cyber attacks, data security issues can discourage the use of e-learning tools.

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- Changes in engineering education regulations may affect the applicability of blended learning.
- Inequalities in access to adequate computer equipment and a stable internet connection can hinder participation in online classes. Not all students have equal access to modern technology, which can affect their learning opportunities.

The blended learning model in materials engineering education effectively combines the advantages of traditional classroom teaching with the flexibility of online learning. Laboratory and practical classes delivered in a classroom setting allow students to gain key practical skills working with real materials and equipment. At the same time, the online learning opportunity gives students the chance to learn independently, which promotes a better understanding of the theoretical aspects of the subject.

However, blended learning is not without its challenges. Both students and teachers are faced with the need to master and effectively use a variety of digital tools, which is not always easy. Lecturers face the task of adapting teaching materials to a hybrid model, which requires time, creativity and familiarity with technology. Creating engaging content and maintaining interaction in an online environment can be difficult for some, especially when students have limited access to technological resources or prefer more traditional teaching methods.

For students, challenges include the need for self-discipline and effective time management, which is crucial for success in the hybrid model. The lack of face-to-face contact with the lecturer in some parts of the course can limit the sense of learning community, which affects students' motivation and commitment to learning. At the same time, however, these challenges provide an opportunity to develop skills such as time management and self-reliance, which are valued in the job market.

4.2. Tools for Creating Teaching Materials for Hybrid Learning

The creation of high-quality learning resources, adapted to the requirements of hybrid learning, is a key challenge for today's lecturers. In an era of rapidly evolving information and communication technologies, a wide range of software and platforms are available to support the design, management and distribution of learning resources. Due to the sophistication of these tools, some teaching staff may encounter difficulties in implementing them effectively. In order to support lecturers in the process of creating modern educational materials, a set of tools is proposed, guided by the following:

- **Intuitiveness and ease of use**: Selection of tools with a user-friendly, easy-to-use interface, allowing for a smooth start, regardless of the level of knowledge of the technology. Priority is given to solutions that do not require advanced technical knowledge, allowing widespread access to tools among lecturers of varying levels of experience.
- **Gradual adaptation**: tools that enable new functions to be implemented in stages, allowing lecturers to develop their competences at a pace that suits their individual preferences.
- **Comprehensive instructional support**: Tools for which an extensive database of instructional material is available, including video tutorials, step-by-step guides and support forums, making it easy to improve skills yourself and solve problems efficiently.
- **Synergy with traditional teaching methods**: Solutions that complement and enrich traditional teaching methods, creating a coherent educational ecosystem in which new technologies coexist with tried-and-tested teaching approaches.
- **Compatibility and integration**: Tools that enable the export of content in formats compatible with popular educational platforms and ensure seamless integration with different types of educational material. Priority is given to solutions that support the smooth deployment of learning resources in a variety of environments.

Based on an analysis of key teaching needs, the selected tools have been grouped into four main categories that correspond to the most relevant areas of educational resource creation:

- **Multimedia presentations**: Tools for creating attractive and interactive presentations to support the visualisation of content and reinforce the teaching message.
- **Computer graphics**: programmes enabling the design of graphics and visualisations that can enrich teaching content and support student learning.
- **Video editing**: Video creation and editing software to produce engaging video lessons, including lectures, presentations and tutorials.

- **Audio processing**: Audio editing tools that support the preparation of professional audio recordings, e.g. for educational podcasts or voiceover recordings.

Each of these categories contains tools of varying degrees of sophistication, allowing lecturers to choose the solutions best suited to their needs and skills. By using such tools, the process of creating and implementing learning materials becomes more efficient and the resulting resources support interaction and student engagement in the learning environment.

An overview of presentation creation tools, including how they can be easily shared on learning platforms such as Moodle or Microsoft Teams.

Microsoft PowerPoint

Description: PowerPoint is a popular presentation creation tool that offers a wide range of features such as animations, transitions and multimedia embedding. With a user-friendly interface and built-in templates, users can quickly create professional presentations.

Platform integration: PowerPoint allows presentations to be easily exported to formats supported by Moodle and Microsoft Teams, enabling them to be quickly shared with students and teaching teams.

Link: https://www.microsoft.com/microsoft-365/powerpoint

Google Slides

Description: Google Slides is a free, cloud-based presentation tool that enables real-time collaboration. As part of Google Workspace, it is particularly useful for those working in an online environment.

Platform integration: Google Slides presentations can be easily embedded in Moodle or shared in Microsoft Teams via links to the cloud, facilitating direct access for students and colleagues.

Link: https://www.google.com/slides/about/

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Canva

Description: Canva offers the ability to create aesthetically pleasing presentations with its wide range of templates and easy-to-use graphic design tools. The intuitive interface makes Canva accessible even to users with no design experience.

Platform integration: Canva allows export to PDF and presentation formats that can be easily uploaded to Moodle or Teams, providing easy access and visually appealing teaching material.

Link: https://www.canva.com/

LibreOffice Impress

Description: Impress, part of the free LibreOffice suite, is an offline tool for editing presentations, offering basic features such as animations and multimedia embedding. A good option for those who prefer a solution that works without an internet connection.

Platform integration: Impress supports export to Moodle and Microsoft Teams-compatible formats, enabling presentations to be quickly made available in formats friendly to educational platforms.

Link: https://www.libreoffice.org/discover/impress/

Overview of graphics processing tools.

Pixlr

Description: Free online photo editor with basic editing functions such as cropping, colour adjustment and effects, with a simple beginner-friendly interface.

Link: https://pixlr.com/

GIMP

Description: Free open-source raster graphics editor with Photoshop-like features such as layers, filters and retouching tools, ideal for more advanced users.

Link: https://www.gimp.org/

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Inkscape

Description: Free vector graphics tool, perfect for designing logos, illustrations and diagrams. Requires more precision and knowledge of vector graphics.

Link: https://inkscape.org/

Adobe Photoshop

Description: Professional, advanced raster graphics editing tool, offering full control over your project with features such as layers, masks and advanced retouching tools.

Link: https://www.adobe.com/products/photoshop.html

Overview of video processing tools

Camtasia

Description: A versatile screen recording and video editing tool, ideal for creating tutorials, online courses and presentations. Camtasia is beginner-friendly, offering features such as adding effects, transitions and narration, making it a popular choice for educators.

Link: https://www.techsmith.com/camtasia.html

DaVinci Resolve

Description: A free program for professional video editing and colour correction, offering a wide range of advanced features such as multi-track editing, visual effects, surround sound and post-production. DaVinci Resolve is popular with semi-professional and professional video editors, especially in the film and television industry.

Link: https://www.blackmagicdesign.com/products/davinciresolve/

Overview of sound processing tools

Audacity

Description: Free and open-source audio editing tool that allows you to record, trim, mix and enhance audio recordings. Ideal for voiceover recordings, podcasts and audio track editing.

Link: https://www.audacityteam.org/

Evaluudio

Description: Free and intuitive audio editing tool, suitable for less advanced users. Offers trimming, audio correction and effects functions, ideal for basic editing of recordings.

Link: https://www.ocenaudio.com/

Educational platforms to support hybrid learning.

Moodle

Description: One of the most popular open-source e-learning platforms that enables the creation of online courses, the management of learning materials and communication between teachers and students. It is flexible and suitable for various forms of teaching - from stand-alone courses to hybrid classes. With numerous features such as quizzes, discussion forums, assessments and assignments, it supports diverse working methods and facilitates remote management of the educational process.

Link: https://moodle.org

Microsoft Teams

Description: Microsoft Teams is an online collaboration and communication tool, particularly useful for synchronous teaching and remote classroom management. It allows you to hold video meetings, organise live classes, share teaching materials, chat and collaborate on documents in real time. Integration with other Microsoft 365 applications, such as OneNote, Word and Excel, allows tasks and projects to be organised efficiently, so lecturers can effectively manage student group work. Teams provides access to all the necessary remote learning and collaboration tools in one place, facilitating communication and supporting the fluidity and efficiency of teaching.

Link: https://www.microsoft.com/en/microsoft-teams

Nowadays, with online education gaining popularity, there are many innovative tools available that significantly support the process of creating and sharing learning materials. However, it should be noted that many of these tools are commercial in nature and come at a high cost. the high price and

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complexity of these solutions may discourage some lecturers, especially those who are new to hybrid learning. In response to these challenges, the proposed toolbox focuses on accessible, easy-to-use and relatively low-cost tools that enable the creation of engaging learning materials without the need to invest in expensive software.

With intuitive interfaces and comprehensive instructional support, the proposed solutions allow for the effective implementation of educational content and the development of digital competences. Lecturers, with their diverse technological skills, can become creators, independently creating educational materials in an accessible and comfortable way. This approach is crucial in the context of diverse digital skills among teachers.

The next stage may be to reach for more advanced tools as lecturers feel more confident in their craft and gain experience in creating e-learning materials. They will then be able to exploit the full potential of more sophisticated solutions, such as Articulate Storyline 360 or Adobe Captivate, which offer broader capabilities.

4.3. Blended Learning Teaching Methodology

Effective teaching in the blended learning model requires an appropriate combination of different forms of teaching and the adaptation of the methodology to the specifics of the subject and the needs of the students. It is crucial to maintain a balance between asynchronous, synchronous and stationary classes, while ensuring high quality learning and the achievement of the set learning objectives.

The blended learning model allows flexible adaptation of the lessons to the course requirements, the students' level of sophistication and the technical and organisational conditions of the university. The teaching materials prepared by the project partners are designed to be flexibly adapted to a variety of needs and learning contexts. Using these resources, teachers can freely modify and adapt the materials, taking into account the specifics of the subject, the students' level of proficiency, as well as the available technical capabilities. As a result, the content can be used effectively in both desktop and online environments, allowing for the introduction of individual teaching methods and the adaptation of materials to meet the unique requirements of the group.

The project team recommends a blended learning structure that combines five key elements: asynchronous preparation, synchronous online sessions, desktop labs, an asynchronous follow-up session and individual discussion of results.

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1. Asynchronous learning (Moodle)

Asynchronous learning allows students to learn at their own pace, which promotes effective learning and increases student engagement. The Moodle platform allows a variety of learning resources to be uploaded and available to students at any time. Useful resources include:

- **Multimedia presentations**: Introduce basic issues and concepts that students can learn on their own, making subsequent content easier to understand.
- **Teaching materials and instructions**: Documents and presentations with instructions for tasks or experiments that students should perform prior to synchronous or stationary activities.
- **Quizzes and tests**: Short quizzes or tests help students test their knowledge and preparation for the next steps in the course. The teacher should choose an appropriate pre-test activity, such as a quiz, written reflection or forum discussion, to assess students' level of preparation.
- **Discussion forum**: The forum provides a space to exchange views and ask questions. Students can address issues and concerns on an ongoing basis, facilitating further learning.

2. Synchronous online sessions (Microsoft Teams)

Online synchronous sessions provide students with direct contact with the teacher and real-time interaction to support understanding of more complex topics. Classes delivered on the Microsoft Teams platform include:

- **Live lectures**: Presentation and discussion of more complex topics that require direct explanations and interaction with the teacher.
- **Group discussions**: working in small teams (e.g. in breakout rooms) fosters the integration of students, enabling them to solve problems and analyse tasks together.
- **Q&A sessions**: live meetings where students can ask questions about asynchronous material or preparation for classroom activities. This helps them to understand more difficult issues.
- **Group work**: Division into working groups in which students analyse cases or perform problem tasks appropriate to the topic of the class. The results of the group work can then be discussed in the forum or in the following class.

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3. Stationary laboratories

Laboratory classes are a key part of technical teaching, especially in subjects such as materials engineering. They allow students to apply theoretical knowledge to real-world conditions and gain practical experience.

4. Asynchronous follow-up session after the laboratory

Once the reports have been uploaded to Moodle, it is useful to run an asynchronous follow-up session so that students have the opportunity to reflect on the results and further develop their knowledge. This session can include suggestions for:

- **Supplementary tasks**: Additional exercises or analytical tasks related to the lab results that will allow students to reiterate key concepts and reflect on the practical application of the results.
- **Reflection and analysis forum**: Create a dedicated discussion forum on Moodle or Teams where students can share their thoughts, ask questions and discuss difficulties they have encountered in analysing the results.

5. Synchronous discussion of results (Microsoft Teams)

At the end of the cycle, it is useful to conduct an individual discussion of the results during a synchronous session on the Microsoft Teams platform. This session allows you to approach each student individually and provide detailed feedback. Elements of this meeting may include:

- **Individual performance consultation**: The teacher discusses his/her report with each student individually, clarifying any ambiguities, commenting on how the exercises were carried out and pointing out areas for improvement.
- **Questions and answers**: The session allows students to ask additional questions and deepen their understanding of the process and results, which promotes better preparation for future laboratory tasks and exercises.

4.4. Materials Science Masters - Blended Learning: Future Challenges and Directions

The implementation of blended learning in the Materials Science Masters (MSM) programme opens up new avenues of development in materials engineering teaching, while highlighting challenges that require a long-term strategy and continuous improvement. Blended learning bridges the gap between the traditional approach, based on direct laboratory experiences, and the flexibility offered by modern educational technologies. The work on new learning materials has been a significant step forward, but the future requires further development of the methodology, adaptation of the technology to meet changing needs and strengthening the role of the teacher as creator, innovator and guide in the world of knowledge. Blended learning in MSM requires teachers not only to be able to use a variety of digital tools to support the teaching process, but also to be flexible and ready to learn. In the long term, it is crucial to place particular emphasis on developing teachers' digital competences through regular training and providing access to new technologies. Especially since the rapid development of artificial intelligence will redefine the role of the teacher, making him or her a guide to support students in the informed and responsible use of modern tools and to develop their critical thinking capacity.

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5. Competence, Experience, Qualifications of Training Staff

The proposed study programme for the Materials Science Masters project is the result of a collaboration between specialists from different disciplines, representing the four partner universities. The programme is made up of nine thematic blocks with a total of 80 modules. This structure provides a comprehensive and interdisciplinary approach to education in the field of materials science.

In order to successfully implement the programme at other universities, it is important to start with an assessment of the institution's staff resources. An analysis of the competences and experience of the available teaching staff will allow the selection of those modules that best match the specialisations and capabilities of the academic staff. This flexible approach makes it possible to adapt the programme to the specificities of each university, while ensuring a high level of teaching within the selected topics.

In order to facilitate the process of assigning academic staff to relevant programme modules, it is recommended that a uniform format for the characterisation of teaching staff is developed. Such a standardised description should include key information such as:

- Education and degrees
- Areas of specialisation and research interest
- Publications output, including key articles and monographs
- Teaching experience, including courses taught and innovative teaching methods
- Work experience outside the academy relevant to the subjects taught
- Participation in research projects and grants
- International cooperation and internships abroad
- Prizes and awards for scientific and teaching activities

The uniform description format will make it easier to compare the competences of individual teachers and assign them to the relevant programme modules. This will enable universities to make optimal use of the potential of their teaching staff, ensuring that students have access to the knowledge and experience of the best specialists in their field.

Below is a sample table that can be used to describe the characteristics of academic teachers and other persons conducting classes or groups of classes. The table has been prepared on the basis of the recommendations of the Polish Accreditation Committee included in the *Templates of self-assessment reports*, available on the PKA website (accessed 27 October 2024): https://pka.edu.pl/dla-uczelni/wzory-raportow-samooceny/ .

Characteristics of academic staff and other persons teaching a class or group of classes

Name:

Academic title/discipline, degree/discipline and discipline, professional title (in the case of a medical degree, specialisation), year in which the degree/degree/professional title was obtained:
List of classes/classes and hours previously taught by an academic teacher or other person
Characteristics of scientific achievements with the indication of the fields of science and scientific discipline(s) in which they can be found and a list of at most 10 most important scientific achievements with particular emphasis on the last 6 years, together with the dates of their attainment (scientific publications/artistic achievements, patents and protection rights, completed research projects, national/international awards for scientific/artistic achievements), with particular emphasis on the achievements related to the field of study.
Characteristics of teaching experience and achievements and a list of at most 10 most important teaching achievements with particular emphasis on the last 6 years, indicating the dates of their attainment (e.g. authorship of textbooks/didactic materials, implemented teaching innovations, awards received by students who were supervised by the academic teacher, supervision of a scientific circle, teaching at a foreign university, e.g. as part of academic teacher mobility.
Description of the work experience in relation to the learning objectives, the learning outcomes assumed for the course and the programme content.

Polish Accreditation Commission, Templates of self-assessment reports, accessed 27 October 2024, https://pka.edu.pl/dla-uczelni/wzory-raportow-samooceny/.

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6. Educational Infrastructure and Resources Used in the Delivery of the Study Programme

In order to successfully implement and deliver the Materials Science Masters programme, it is crucial that the university has the right infrastructure and educational resources. Providing the right technical and teaching facilities is the foundation for the effective education of future materials engineers.

The study programme was developed by a consortium of four partner universities, which allowed the use of a diverse infrastructure and the provision of a rich subject matter.

The developed guides for each module include a list of the key apparatus required for the laboratory and practical exercises. Before proceeding with the proposed programme of study, we recommend that a detailed assessment of the available resources is carried out to ensure that the university is able to provide the right conditions for learning and achieving the intended learning outcomes. This process includes not only an inventory of existing equipment, but also a needs analysis and planning for possible investments to fill the gaps. This approach ensures that students have access to the modern tools and technologies necessary to develop their practical and theoretical skills. It is also necessary to take into account the maintenance and updating aspects of the equipment to ensure that the teaching process is continuous and up-to-date.

The proposed programme consists of thematic blocks that cover a total of 80 different subjects. A university wishing to implement the curriculum has the opportunity to choose the modules that best suit its specific conditions and needs. This approach allows local labour market conditions, technological advances or student preferences to be taken into account. However, any modification must be preceded by a detailed analysis of whether the available infrastructural resources allow the achievement of the intended learning outcomes. The introduction of changes must not lower the quality of education or reduce the range of skills and knowledge required. When making changes, it is also important to ensure that any adaptations follow the hierarchical structure of the programme as described in the chapter "Methodology of Curriculum Development: A Hierarchical Approach", which ensures the integrity and consistency of the learning within the proposed Materials Science Masters programme of study.

Therefore, the process of modifying the study programme should be carried out with the utmost care, taking into account the opinions of industry experts, academic staff and the needs of the labour market. Such an approach ensures that graduates of the Materials Engineering degree programme will have competencies that meet the current requirements of industry and science, while maintaining high educational standards. Thus, the university can ensure that its graduates are fully prepared to meet professional challenges, as well as for further academic and professional development.

Implementing a new degree programme is a complex process that requires the commitment of many resources and the cooperation of various university departments. Careful infrastructural analysis and investment in appropriate equipment are crucial to the success of the programme.

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7. Bridging the Gap: Enhancing Practical Skills and Industry Collaboration in Materials Science and Engineering Education

The industry and problem-driven-solution-generating sectors play a critical role in the advancement of technology and science, which, consecutively, contribute to the betterment of the society. Furthermore, they are helpful and instrumental in the enhancement of educational standards in specific domains of everyday life. A modern educational system is ultimately important for the technological and hence industrial development but the investment in higher education tend to have better outcomes in terms of academic and industrial progress. It is crucial to establish a collaborative relationship between the industry and the educational institutions, particularly through the provision/providing of training opportunities for undergraduate and graduate students. Such educational related initiatives can promote mutual benefit through the development of internship programs, which can assist to form a productive and beneficial working relationship between industry and academic and research partners.

The survey, which gathered opinions from students and practitioners in IO1 stage, indicated that MSc students in general and Materials Science and Engineering graduates in particular may benefit from a greater focus on practical approaches that have been the centre of the industry for years. The literature research and the collected results from IO1 surveys show that the developed programs are considered at a reasonable level in terms of content by the respondents some of whom are also engineers that hold MSc and PhD degrees. However, all academic institutions, students and practitioners could benefit from some improvement and modernisation in light of the modern labour market challenges in Materials Science and Engineering and Metallurgical Engineering, too.

It was suggested in the IO1 survey results that maintaining the overall outline of the programme could be easier if there were more practical classes and specialised English content for those interested in working abroad. The language ability was prime concern of students or engineers who are also willing to step in research and development or even design facilities within their companies or in another country or possibly in more international and institutionalised companies.

In the case of results concerning the essential needs that could help in the work carried out or continuing education, the respondents emphasize the importance of developing practical problem-solving skills and working in laboratories. In addition, they note the importance of research tools which help them connect to the academic world. One way of doing this could be to introduce the form of seminar classes or replace the form of lectures with examples in conjunction with the theory focusing on the so-called "case study". It would be beneficial to analyze cases that have actually occurred or been encountered in the industry. The analysis of the questionnaires suggests that there may be a need to increase the number of classes covering research methods and techniques. It seems that the application of the learned knowledge in practice could be improved, with most answers indicating that it is at an average or poor level. This may indicate a need to reduce the inflow/amount of theoretical knowledge and increase the practical knowledge.

The results of the IO1 survey in this project indicate that most of respondents place a high value on the acquisition of practical problem-solving skills and experience in laboratories. This suggests the incorporation of more hands-on, experiential learning opportunities. The survey also recommends the replacement of traditional lectures with a format that combines theory and practice, such as seminars or case studies based on real examples from industry. The analysis of actual incidents and practices encountered in industry should be the focus.

It is also revealed in our surveys that the industrial sectors are general open to collaborations in many areas related to improvement and management in their production routine with universities in many engineering topics and also in Materials Science and Engineering. The shortcomings revealed in sections 1 and 2 in our industry and student survey in IO1 stage prompted industry representatives to propose modules that could enhance the knowledge, skills, and competencies of employed materials engineering graduates. These modules were particularly focused on microstructural characterisation and analysis, numerical modelling in heat treatment, image processing in materials science and engineering, microstructure and property interactions, testing standards in quality control procedures, and surface science/ tribology/ mechanism. One proposed solution was that the institution would maintain these modules in the curriculum, or alternatively, close some of them and introduce new ones that would be beneficial to students. It was recommended that focusing the subject of diploma theses on the problems faced by the industry would be a way forward to increase the cooperation with industry. Furthermore, the joint conduction of these thesis studies will also open up an opportunity between the university and industry, by exploring their capacities and instrumentation for research and development. The University would/ should be sympathetic and amenable/open to industry's request for increased practical classes, provided that the use of industrial facilities for thesis studies and industrial training opportunities for students with limited interactions that are not directly linked to manufacturing or heavy production facilities is also permitted.

7.1. The Needs for Industry Oriented Courses in Higher Education

It is evident that the role of engineers in society and industrial development cannot be denied or underestimated. Indeed, the majority of scientific advancements are turned into practice by engineers through their experience in relevant areas of work or invention or educational activities that are relevant

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to their subject of interest. Consequently, it is important for educational system to have an established relationship especially with academic institutions where the training of students take place but not sufficient or in par with the technological development with comparatively vastly resourced industry. It is another aspect of the problem which was defined by the respondents in this project outcome of IO1 that the most of the graduates / students who responded to the survey stated that the employment position and working conditions in their work place is part of the reason that they or their friends were having problem with completing their higher education. The overtime at work and strictly demanded attendance into production projects in workplace and the gravity of the travelling for servicing and customer relations issues are a few reasons that keep students of MSc and PhD programs away from studying. It is also possible to state that family issues are one of the problems with married or prospectively married or coupled students such that the requirement of being called upon natural duty of each partner may also hinder the educational progress. Albeit to family problems issues, the duty of looking after one or more of the family members and also support them in any way possible was also affirmed by the respondents. Survey also reported that some students were also had to give up or leave the course for the help of their relatives. However, the work related problems appear to be prevailing compared to other family and other related problems. In addition to these work related problems, it is worrying that the engineering degree is preferred less in Europe and in the world in general, and what is more worrying is that Gaussian distribution of engineering subjects are slightly accumulating towards few subjects of engineering, i.e. this is likely to be attributable to a specific subjects of computer engineering, software engineering, mechanical engineering, electrical and electronics engineering and / or aerospace engineering etc..., and this affects the higher education, innovation, and research and development process in both universities and companies dramatically due to the fact that it leads to less students enrolling to MSc courses from the same discipline or more students dissimilar disciplines but close disciplines such as mechanical engineering, automotive engineering, chemical engineering. This would pose a question if these dissimilar discipline students are well equipped with the content of the course or more specific rooting towards certain subjects are thought in the course that suits the needs for these students. Although there are many deep rooted problems in the approach, a simple solution is to amend the curriculum and course content to cover all sub-disciplines and course contents that go with it. This way students are content with the program and administrators are partly content with it but the topic with which professors work may have to change or shift its direction towards the needs of students and industry altogether. There are very little happy ending solutions. The solution that universities are seeking for these real problems is highly pertinent to the contemporary iterations of the educational and academic disposition and award system; it is either a join to our "clinically" proven ideas of or perish with your over qualified and specific doctorated field of application. This is solely opinion of this writer that it is similar to publish or perish: a conceptual periphery attitude; the imperative to publish or perish is a pervasive phenomenon in academic institutions, where it has the effect of influencing the conceptual academic capacity of those within the institution.

Integrating a similar topical educational system is a complex undertaking, but not an insurmountable one. On the other hand, integrating a distinctive educational system is a time-consuming process, and in some cases, the most effective solution may be to simply close the department or the program down. This may follow an extreme example of the waste of years of training and the forcing of people to be trained in a subject where one can get by with a PhD or MSc. It is as difficult to accept as a paradigm shift in time. It is not welcomed with gratitude but with regret.

7.2. The Curriculum: In-Class Activities in Liaison with Internship and Training

If the curriculum of the programme and the university allow the industrial level practice and training integrated into the Master's programme, there should be a leverage to adopt such system to circumvent the problems observed and experienced by potential and present students of Masters programs. As were stated before based on the survey results of IO1, problems included work related difficulties purely from the employment condition, family related problems such as having a relative(s) who are in need of being looked after financially, physically or mentally and duties couples for their everyday life activities or offspring needing the parental intuition. These problems also included the financial difficulties prior to and after graduation from undergraduate course as well as distance travelled from the central place of residence to the place of study.

The practical training comes in two different concepts: in-class activities including laboratory activities and internship. The first branch involves the practical in-class entertainment or in class activities and the most importantly laboratory activities for better learning the subject through exploring trial error cycle during experimenting and guided learning procedure. Guided learning is an important phase of learning as they provide the most intriguing and complicated teaching with its capacity of making students think and practice their knowledge. Within the project concept, which is one of the basics of this project outcome, it becomes more concentrated and focused on certain aspects of the subjects which are more beneficial to students. Practical training can also include computer usage during the class activities with regards to observe some important features of the lecture such as finite element analysis modelling of deformation of sheet metal during bending operation, heat distribution during welding and its modelling with different base metals as opposed to low carbon steels base metal or statistical analysis of results from point counting measurements from the microstructural analysis of some weld metal or heat treated specimens and many may follow these examples. The advantage of these activities are that they preclude incomplete learning of the subject should it be taught with an intention of covering wide range of subjects and touching as many examples as possible within the scope of the subject.

In class activities should contain another important application: the case study by using real specimens and practical training for the analysis of defects, its history etc... This is very close one to the real cases derived from the real world examples and it should be very much encouraged. Students should carry out the analysis of defects i.e. measure and observe, or different or several important aspects of the usage of relevant part or material that these materials are produced from. As was also partly emphasized in the IO1 survey results that the case study is important part of in class activities and relevant to the practical training and hence following remarks are observed by students as they are more relevant to the case study of parts that are being studied:

1. If the case study parts are brought into the classroom, students feel the texture and be able to measure the dimensions of specimens and defects. What is more important is that the students can take notes based on their observations and share it with other students; this is essential for the hands on experience and learned practical training.
2. Students ask relevant questions about the origin of specimens such as where it was obtained, the origin of the part from which it was extracted or how it was brought to the classroom, the total history of manufacturing if possible, and observe the procedures for resolving the case.
3. Having gained a confidence in case study procedures, students also learn the practical solutions and implement them, giving them a further confidence in application of knowledge obtained in the classroom. It is also an opportunity for students to question the methodology of finding the cause and procedural differences as well as standard procedures.

As was shown above that, such activities should be implemented in higher education courses in order to encourage the learning process and may also be inserted in to the blended learning courses where and if possible. These activities are essential for the better understanding of the subject from the perspective of students. In class activities are usually set up by the instructor and performed by either both instructor or assistants.

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7.3. How to determine the success of students who are enrolled in internship and thesis by industrial problem solving derivative

The success of internship may be determined by the research and development or industrial institution and in conjunction with sending organisation i.e. the University or educational institution. The degree of success of intern may be determined by the marks given based on the achievement in projects that students have been the part of and with a conjunct opinion of the leading scientist or the nearest academically relevant and sufficient supervisor and on the opposing side, the supervisor in academic institutions. This may provide consistency and relevance of marks provided and also may lead to the invitation of leading scientist or on site supervisor who holds PhD degree for the jury duty for the defense of student's thesis. It will be a meeting with a valuable exchange of ideas for further work and cooperation. The membership of thesis committee duty should be considered primarily based on the on-site supervisor's experience and priority for the curriculum design as it may be opposed by the institution's higher education curriculum committee.

7.4. What is expected from Materials Science Masters project: what is the driving force to implement the effect of industry?

The change in the behaviour of the younger generation in society is forcing a systematic change in the establishment for a more inclusive society. Behavioural change indicates that the society is evolving for different level of technological and behavioural shifting in attitudes towards generational behaviour which gives rise to distinct perspectives and ways of approaching life. Norms and values evolve with time, causing differences in cultural perspectives between generations. These disparities can impact relationships, causing conflicts over issues like social norms, lifestyles, and even family traditions. This evolution shows itself also in the work culture and may be identified in the form of quitting jobs or changing jobs easier than older generation and also direct themselves into more popular attractive professions. The less human interaction, dependence on technology, being very meticulous on the subject and being less tolerant of opposing opinions or behaviours, that are also called cancel culture affect educational development of the society in a different way. This manifests itself in the number of students choosing conventional subjects that formed the society and technology in many aspects. The number of students successfully completing any MSc courses in many subjects is falling down dramatically due to the employment of students or potential candidates for MSc courses. However, this may pose an important opportunity for Materials Science Master's programme and a versatile reprogramming through blended learning and syllabus modification in addition to student enrolment conditions can be implemented into the Materials Science Master's course. Such implementation will also be a completion of a requirement stated by survey results which indicated that students who are in employment are in an immediate need of such implementation in order to complete their studies or it may help them decide to go for MSc courses for various reasons. Such needs can be met with those implementations that are needed for such students or candidates.

The stage of student enrolment can be further analysed as to what sort of needs are required by students. The first of these needs is the easy route of acceptance of students or candidates by the course committee however it may lead to the enrolment policy to be changed in favour of students who are in employment. This may be a decorative issue but the benefit for the course would be tremendous as it will lead to the cooperation opportunities between academic institutions and well established or small scale business institutions. This may be further analysed by the addition of certain acceptance rules such as the size and the most importantly number of workers in the sending company. It would be relevant to the course aims for companies to have a department of research and development and have a compulsory or selective cooperation with the help of viable problem solving capacity between academic institution and business institution. It is an important at this stage that the cooperation is more relevant to the Materials Science Master's course as it may also help the reputation of the course for being directly tailored for the industry needs. Although it may seem to do so, a further reputation maker such as weekend courses and also evening courses may also be considered for that purpose. It is much reciprocated action for the benefit of students; nevertheless, the evening courses may not prove to be useful but rather blended learning process where students are given a time window to complete course content with a reasonable course schedule. This is also implemented in this project.

One of the survey questions in IO1 stage was about the remote learning process for which almost 60 percent of the students are in favour of it. This may be explained the easiness of listening to the lecture and take notes. It may be expected from students who are working with a selection of online attendance which may be designed within a predetermined time schedule with students in accoradance with the schedule of professor. It is possible that this may be tolerated by the employers since the time to travel to institution may not be lost during the working hours and employees can also be called upon on urgency of the situation in factory or work place. However, the employer should be aware of the fact that the course completion is important for the employers who are enrolled in this course for his or her and even for the company.

In most countries, students of Master's and Doctorate programs are given official leave per week until the completion of their study and most institutions are beneficially assuming this situation with

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the hope that the company may benefit greatly with the statistics of employee quality and their educational advancement within the company as against the requirements and responsibilities to higher authoritarian institutions such as Ministry of Education and Ministry of Technology and Industry and even relevant European Union sub institutions. It will also be intriguing activity for the company that such statistics may also help with the national and inter European and even international projects that are relevant in their field of manufacturing. Nevertheless this may be farfetched proposition for some companies but rather will be beneficial for some companies; this should be well explained to students and company representatives of sending institutions how pivotal it is for them and students.

In addition to implementation of enrolment into the course, the informative activities can also be planned intermittently by designing a course in which class activity is encouraged. Student's attendance is crucial in in-class activities as they are primarily important part of learning process, as it encourages a deeper understanding of the subject matter, enhances communication skills, and promotes active learning. The training in labs and training through in class activities are two important stages in designed project learning process.

Furthermore, it may be beneficial to consider incorporating various classroom activities to enhance the learning experience. These activities could include brainstorming, drawing, group assignments, and role-playing, which could help students develop a range of skills and promote a more engaging learning environment.

The benefits of participating in class can be essential for the students in the sense that active class participation helps students better understand the course material being taught by clarifying concepts and encouraging them to ask questions and benefit from the questions being asked in classroom. As our industry and students opinion survey indicated that, one of the main problems in student retention is the lack of interest of students in the course schedule that lectures are conveniently structured for the benefit of institution however, students are less keen on attending lectures as their schedule is more leaning towards either the weekends or holidays that are predetermined for their convenience. This sparks another issue that if the institution should give in such a schedule adjustment, whether it helps students follow the course or be rather beneficial for their learning progress. This seems an internal determination issue for the program developers for the higher education courses. It is well determined that, for students who find difficult to follow the course, engaging in class discussions and activities or at least follow the discussions increase the likelihood of remembering what was taught and discussed in detail, leading to better retention of information. It will also eventually results in higher grades on exams or practical classes.

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One of the comments from employers in IO1 survey results was that the students are lacking in "critical thinking" when it comes to the development of behavioural or work place skills. These would include to attend to the problems faced by human to human interactions and to address the low level employees and also high rank employees such as supervisors or as we generally put "the hierarchical ladder" that are listed ranks according to relative status or authority.

Students are influenced by each other and developing a sense of critical thinking skills may be affected by class participation, case studies and practical classes that require students to analyze information and form opinions based on evidence they are given or in their hand, which visibly helps develop critical thinking skills in addition to the real work conditions in manufacturing or production. It will also develop a confidence in expressing themselves and speaking up in class can help students build confidence in their own ideas and abilities, which can carry over into other areas of life. This will eventually help enhance the communication skills which will improve practical communication skills, including active listening, articulating ideas clearly, and responding to feedback. This is also a useful skill in the work place environment as was stated in our survey results from IO1 stage of the project.

Another useful skill is the teamwork that has been in the centre of industrial institutions, which is sometimes used to measure the efficiency of workers and / or units in the factory or the department. As many in class activities involve working in groups or pairs that help students develop teamwork skills such as collaboration, compromise, and conflict resolution within the given team assignment. Considering that there are two different schemes of student enrolment, this part of Masters course, that is in class activities and practical classes, are more useful for normal enrolment procedures, however, the industrial thesis enrolment students may also benefit in great deal even it is a short duration of time. It is generally thought and stated before that the in-class activities are beneficial for active learning, and that participating in class promotes active learning, which involves engaging with the material rather than passively listening to a lecture. However, it is also assumed that the blended learning is a supplementary to the actual learning process in normal route, but is essential in industry thesis route. This could be similarised with case study activities where students actively participate in class, and they are more likely to be engaged and interested in the material being taught, leading to a more enjoyable learning experience. For both group of students, the participation in class activities allows students to receive feedback from their peers and teachers, which helps them identify improvement areas and adjust their learning approach during and after the course have been taught. This is very important stage for professors who teach the course, for the improvement course material and teaching style in the classroom. The teaching style will also improve the learning experience and will be eventually reflected to the final marks from in class essay assignments and laboratory reports.

Hence active class activities are believed to be leading to better grades, as students who understand the material better and engage in the learning process are likely to perform well on assignments and exams.

7.5. Internships and practical training and cooperation with industry

The educational system aims to inspire learned practices through theoretical knowledge. The internship is more about learning than practical training. This is because the nature of the internship is to experience the real working environment and learn the procedures quicker than training. Students are expected to gain important benefits through the internship because of the hands-on experience.

Internships and training are essential components of the educational experience, offering students and employers numerous benefits that can lead to a long-term career success and personal development. Internships and training also provides students with the practical skills and experience needed to succeed in their chosen careers. By integrating workforce training into higher education, institutions can ensure that their graduates are well-equipped to contribute to and thrive in a rapidly changing world.

Many colleges and universities prioritize experimental learning procedures, requiring students to participate in internships or other forms of hands-on training such as laboratory tests.

Internships in higher education offer a different perspective with respect to opportunities compared with undergraduate studies. While not a compulsory part of education, they provide substantial benefits, including the potential to rapidly transform into finding a job, finding a better-paying job, and also going up the ladder in the corporate structure. Internships offer numerous benefits to both students and employers. Internships provide students with practical experience, allowing them to apply theoretical knowledge in real-world settings, develop essential skills, and gain valuable work experience. Such experiential learning facilitates the growth of students in both professional and personal domains, thereby equipping them with the requisite skills and competencies for successful careers post-graduation.

The importance of practical training is unquestionable in the modern educational system as it provides an important transition between learned knowledge and practical applications. It also bridges the gap between practical application and research-based training, which are lacking in educational institutions and commercial institutions, respectively. However, there is another aspect that is the trained personnel and relatively wide work experience is needed in the manufacturing industry.

The thesis execution in industrial sectors or institution of research and development is of significant importance for the Master's Course and it help fill up the gap created by the management and soft skills and hands on experience expected from the employers and the skills and hands on experience given in educational institutions. Hence, it should be emphasized that even carrying out experiments in industry or research facilities are beneficial for the students in general and it should be considered as part of curriculum of this course in addition to general training and internship. This is because training is typically designed to teach new skills or knowledge to employees, while internships are designed to provide hands-on experience to students or recent graduates. Training programs are usually shorter in duration than internships. Internships and training represent an essential aspect of the educational experience in institutions of higher learning. They provide students with invaluable practical experience, skills, and exposure to their chosen fields, which can significantly enhance their career prospects and personal growth.

By integrating workforce training into higher education, institutions can ensure that their graduates are well-equipped to contribute to and thrive in a rapidly changing world, providing students with the practical skills and experience needed to succeed in their chosen careers. Educational institutions should be attentive and cautious on certain qualities of their graduates, which is valid for their undergraduate and also higher education i.e. post graduates. These factors are relevant to their reputation and capacity of research and development. Following qualities are important for graduates:

1. Skills Gap: Integrating workforce training into higher education is crucial to bridge the skills gap and meet future job market demands.
2. Employability: Workforce training enhances employability by providing students with practical skills and experience that align with industry requirements.
3. Industry Alignment: Workforce training ensures that the curriculum remains current and relevant, adapting to technological advancements and the evolving needs of the economy.
4. Holistic Education: Workforce training promotes innovation and drives economic growth by providing students with an interdisciplinary curriculum that combines STEM fields with soft skills.

7.6. Benefits for Employers or Practitioners

The benefits of cooperation with industry also provide a fresh perspective for the institutionalised workplace. Although, intern students or intern employers bring new ideas and enthusiasm to the workplace, often leading to innovative solutions and fresh insights, it may not always be welcomed for the established practitioners as it may disrupt the production or sometimes it may lead to the spending of valuable resources of the company. However, there is always a positive contribution and positive experience for the interns even though it is otherwise. Nevertheless the training and development of the interns would also benefit for the company. Internships and industrial training and also industrial thesis allow employers to mentor and train students, providing them with the necessary skills and knowledge for future roles and positions in their company as well. Employer responses in our survey in IO1 stage "The market and science environment needs analysis " indicated that the skills gap between those expected by employers and those observed by employers is large and some expectations such as "consider the costs implications of materials used and alternatives, in terms of both time and money", "test materials structure and mechanical properties" and "assess materials for specific properties (such as electrical conductivity, durability, renewability)" can be filled by the course content. One of the benefits of industrial thesis execution and industrial training is to allow employers to identify and assess potential employees, reducing the risk of hiring unqualified candidates for a specific job. It also saves time for employers to find a suitable candidate and employee for that specific job as it can be a cost-effective way for employers to train and evaluate potential employees before committing to full-time positions with an opportunity to develop and mentor future employees, ensuring a steady supply of skilled professionals.

There are many benefits that students and companies get advantage from; these can be classified and short terms and long term benefits. Short terms benefits are generally related to the work force in the case of industrial trainin and internship however, in industrial thesis case, a short time spent on the problem the company facing and a research being conducted on is benefit for short term. If there is a viable solution being offered through this thesis is always a plus for the company.

Long term benefits are usually seen as high cost low impact solutions however in the case of career success, it is imperative for the person to have it in his or her list of to do. Internships have been linked to higher levels of job engagement and wellbeing in graduates, indicating their positive impact on long-term career success. Although, there was no survey entry in our IO1 survey list for the benefits of on-site training, internship and thesis execution in company grounds are believed to be important for the companies and regarded as positive about the initiative when considered their answer regarding the cooperation. The other benefit of internship and on-site training that is beneficial to students is the competitive advantage in job market and within the company or research and development institution. The successful completion of student internship can give students a competitive edge in the job market, as they demonstrate a commitment to professionalism and self-improvement in an ample time of work.

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7.7. How should we setup the cooperation with industry?

The cooperation with industry is multilevel action requiring process. One should comprehend the process of private institutions through their practices of manufacturing and administration. Administrative process is the heart of the private institutions and this should be well understood by the academia where the rules are comparatively less abided by the workers and leaving the job is relatively difficult for the employee since it has many stages of approval. However, the private sector is more relaxed for finding an employee for the benefit of company and whoever is fit the for the position. The other aspect of private sector is the understanding of manufacturing processes and problems related to them. It is mostly a private matter and usually forbidden for an employee to cast out any manufacturing problem to an outsider as it may affect their advertising and marketing as it may also lead to defamation of the firm or company.

Private sector is also is more actively interested in solving their problems with academic institutions specialised in the subject of interest of manufacturing but not really into new techniques or inventions that are not proven to be useful or fully tested. When approaching the private sector hence two approaches should be employed; either problem solving of an existing setbacks within the respected limits of company principles or an improvement of the existing process with small adjustments to the process, this will also have the elements of existing problem. When attaining students to a problem, S/he should be aware of the problem or at least the manufacturing routine of the company.

The cooperation with industry may also be possible with national and international projects. This is although not related to the Masters course curriculum it may end up with cooperation through MSc and PhD students enrolment. This way of attaining students are conditional and students are mostly asked to complete their studies in a very limited time frame but the opportunities of company or private sector is generally well received. One should be aware of the fact that private institutions will have two jobs for one person in this case; one for white collar tasks and project management in which the engineer is asked to contribute to the project and his or her studies while employed and money earning stage.

The survey study results of IO1 stage suggested that employees are not required to be excelled at certain qualities for example “advise on inspection, maintenance and repair procedures” and “develop/design prototypes” but are expected on other skills such as finding a right match of materials for an application with the consideration of cost, time and money are expected highly from students. As seen in Table below that highlighted items are of concerns of employers, and can be focused on these entry items in relation to the cooperation with industry. A relevant evaluation can be made within the institution with regards to employer's expectations and the direction of research with industry.

Employer's expectations

What are your expectations from Materials Science Graduates regarding the competencies necessary to perform the following tasks listed below? (None, Low, Medium, High, Very High)

The graduates of the materials engineering should be able to know how to:

		Priority
1.	select the best combination of materials for specific application	HIGH
2.	test materials to assess how resistant they are to heat, corrosion or chemical attack	HIGH
3.	test materials structure and mechanical properties	HIGH
4.	analyse data using computer modelling software	HIGH
5.	assess materials for specific properties (such as electrical conductivity, durability, renewability)	HIGH
6.	develop/design prototypes	MEDIUM
7.	consider the implications for waste and other environmental pollution issues of any product or process	HIGH
8.	advise on the company's' adaptability to new processes and materials	HIGH
9.	collaborate with others to solve issues arising during the manufacturing process or with the finished product, such as those caused by wear and tear or a change of environment	HIGH
10.	supervise quality control throughout the construction and production process	HIGH
11.	monitor plant conditions and material reactions during use	HIGH
12.	help to ensure that products comply with national and international legal and quality standards	HIGH
13.	advise on inspection, maintenance and repair procedures	MEDIUM
14.	communicate with colleagues in manufacturing, technical and scientific support, purchasing and marketing units	HIGH
15.	supervise the work of materials engineering technicians and other staff	HIGH
16.	consider the costs implications of materials used and alternatives, in terms of both time and money	HIGH
17.	take into account of energy usage in manufacturing and in-service energy savings, e.g. in transport and construction applications.	HIGH
18.	carry out work taking into account the aspects of ecology and environmental protection	HIGH
19.	consciously conduct sustainable development of technological solutions	HIGH
20.	If others, which ones?	

Source: IO1 - The Market and Science Environment Needs Analysis

7.8. Emphasis on the importance of practical experience gained through internships and training in developing professional skills of students

A number of universities in various countries have already implemented internship programmes or industrial placements as part of their undergraduate programmes. A certain period of practical training is integrated into engineering curricula in many universities. This approach is also endorsed and supported by a significant number of potential employers in a range of disciplines. An internship is a form of work experience that is undertaken in the major field of study over the course of one or two semesters or certain number of days. Given that there is a perceived distinction between the competence of engineering graduates and the elemental requirements of the industry, internships are highly valuable for engineering students and also for employers. Typically, students participate in projects, working alongside practicing industrial professionals to address specific, day-to-day challenges. The internship program provides students with an opportunity to gain valuable work experience in their specific field, enhancing their prospects for future employment and engineering careers before graduation. The internship training may be optional or obligatory, depending on the programme concept. The internship is expected to focus on the relevant engineering discipline. It is believed to have positive impacts on all parties, with the exception of interns on field training, who may face some serious challenges. These are varied, such as time limitations for the courses, unsupportive behaviour of companies, exaggerated enterprise privacy or cases with no pocket money or payment. The present study aims to ascertain the impact of internship programmes in engineering and to pose questions that will inform the development of an optimal internship structure.

7.9. How can internships promote personal growth in students

Internships play a crucial role in promoting personal growth in students by providing them with a transformative experience that empowers them to evolve both personally and professionally.

Internships offer students a chance to apply theoretical knowledge in practical settings, allowing them to gain real-world experience and develop essential skills such as time management, teamwork, and leadership. Internships provide opportunities to improve both hard skills like software proficiency and soft skills like communication, problem-solving, and conflict resolution.

Internships offer a chance to build meaningful connections with colleagues, supervisors, and clients, which can lead to lasting professional relationships and job opportunities. Internships help students explore their passions and interests, allowing them to determine if their career choices align with their values and goals. Internships challenge students to step out of their comfort zones, promoting confidence in their abilities and decisions. They learn to work independently, make choices, and take responsibility for their work. Internships introduce students to the nuances of corporate culture, teaching them how to navigate office politics, communicate effectively, and adapt to diverse work environments. Internships help students clarify their career goals by exposing them to various roles and responsibilities. This self-discovery is a crucial aspect of personal and professional growth. Internships provide opportunities to develop leadership and interpersonal skills, such as empathy, conflict resolution, and building rapport. Internships help students develop attention to detail and organizational skills, which are essential for avoiding mistakes and staying productive. Internships challenge students to solve problems and make decisions under pressure, promoting critical thinking and problem-solving skills. Internships help students develop integrity by demonstrating accountability, dependability, and trustworthiness.

They also learn to receive feedback and adapt to new situations. Internships encourage students to reflect on their experiences, promoting self-awareness and personal growth. This reflection can help them identify areas for improvement and develop strategies for overcoming challenges.

Internships are transformative experiences that empower students to evolve both personally and professionally. By providing a balance of facilitators and barriers, internships can promote personal growth by offering opportunities for skill development, networking, exploration, and self-discovery.

7.10. How do practical experiences compare to academic learning in skill development

Practical experiences and academic learning are both essential components of skill development, but they differ in their approach and impact. Academic learning focuses more on theoretical knowledge and understanding. It typically involves lectures, textbooks, and assignments that help students develop foundational knowledge in a subject. Academic learning is critical for building a strong foundation in a particular field and is often the primary method of instruction in traditional educational settings. Practical experiences, on the other hand, involve hands-on activities, projects, and real-world applications that help students develop skills and competencies. These experiences can take various forms, such as internships, apprenticeships, fieldwork, or simulations. Practical experiences are designed to bridge the gap between theoretical knowledge and real-world applications, allowing students to develop practical skills and problem-solving abilities. Practical experiences tend to have higher retention rates compared to academic learning, as students are more engaged and motivated when working on real-world projects. Practical experiences are more transferable to real-world settings, as they provide students with the skills and competencies needed to apply theoretical knowledge in the context of practical. Both academic learning and practical experiences contribute to personal growth, but practical experiences tend to have a more significant impact on confidence, self-efficacy, and problem-solving abilities. Practical experiences are often more valued by employers, as they demonstrate a student's ability to apply theoretical knowledge in real-world settings. Practical experiences can be more cost-effective than academic learning, as they often involve real-world projects and collaborations rather than expensive equipment or facilities.

Both academic learning and practical experiences are essential components of skill development and learning curve in both undergraduate and postgraduate stages. Through Academic learning, a strong foundation in a subject is obtained, while practical experiences in class and through internship help students develop practical skills and competencies that are useful for working environment and non academic sufficiency, too. By combining both approaches, students can gain a comprehensive understanding of a subject and develop the skills needed to succeed in real-world settings.

8. Advisory Board for the Degree Programme in Materials Engineering

In the face of a rapidly changing labour market and continuous technological advances, a key challenge for universities educating materials engineers is to ensure that graduates have the knowledge and skills to meet current industry needs. The concept of the Materials Engineering Curriculum Advisory Board - a body whose main task is to shape the curriculum in close collaboration with business representatives - may be the answer to this challenge.

The Consultative Council provides a platform for dialogue and exchange of experience between academia and industry. Its establishment stems from the conviction that only through the synergy of these two worlds is it possible to create a modern, market-oriented study programme that will provide graduates not only with thorough theoretical knowledge but also with the practical skills sought after by employers.

In this chapter, based on the experience of the partner universities implementing the project, we will propose the structure and composition of the Consultative Council, its key functions and tasks. We will discuss the benefits of the Council for the different stakeholders, as well as the potential challenges and constraints that may arise during its operation. We will also present a set of good practices and recommendations that can contribute to the effective operation of this body, drawing on the knowledge and experience gained by the partner universities during the project.

8.1. Structure and Composition of the Advisory Board

The Advisory Board for the Degree Programme in Materials Engineering should bring together representatives from academia and industry, ensuring a comprehensive view of the educational process. Its membership is recommended to include:

University representatives:

- Vice Dean for Student Affairs,
- Head of department / institute of materials engineering
- Coordinator/Director of the Materials Engineering degree programme,
- Selected representatives of teaching staff, teaching key subjects in the field of materials engineering
- Elected representatives of students of materials engineering

Industry representatives:

- Representatives from leading companies in the materials engineering industry, including, among others, materials manufacturers, companies implementing new technologies, consulting companies and research and development institutes
- Experts in human resources management, recruitment and talent development in companies related to materials engineering
- Representatives of trade associations and organisations for professionals in the field of materials engineering

8.2. Functions and tasks of the Advisory Board

In order to ensure the effective functioning of the Advisory Board for the Degree Programme in Materials Engineering, it is recommended that the following functions and tasks are implemented:

1. Advice on the design of the study programme:

- Conduct regular analysis and evaluation of the current study programme for relevance to industry needs
- Proposing new items or modifications to existing items, taking into account the latest technological trends
- Recommending changes in the ratio between theoretical and practical classes
- Suggesting innovative methods of teaching and evaluating learning outcomes

1. Identification of key competencies sought by employers:

- Organise regular surveys and consultations with industry to identify the most desirable graduate skills
- Conducting a systematic analysis of labour market trends in the materials engineering sector
- Formulation of recommendations for the development of specific competencies within the study programme

2. Supporting the organisation of internships and placements for students:

- Establishing and maintaining regular contacts with companies offering internships and apprenticeships
- Co-developing work placement programmes to ensure students gain valuable experience
- Conduct regular monitoring of the quality and effectiveness of practices and make recommendations for improvement

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3. Initiation and coordination of research and development thesis topics:
    - Identification of current areas of potential cooperation between university and industry in the field of thesis topics
    - Actively support the formation of interdisciplinary research teams made up of academics, company representatives and graduate students
    - Promoting the realisation of dissertations responding to the real R&D needs of companies in the materials engineering sector
    - Provide support in obtaining funding and resources for research and development theses
    - Organise regular competitions for the best theses carried out in cooperation with industry
    - Creation of a database of thesis topics submitted by companies, corresponding to current industry challenges

4. Monitoring of technological trends and labour market needs:
    - Conducting regular analysis of the latest developments in materials engineering
    - Identification of new application areas for materials and material technology
    - Develop forecasts of future labour market needs in the materials engineering sector

5. Evaluation of learning outcomes and formulation of improvement recommendations:
    - Systematic analysis of learning outcomes and student achievement
    - Organise regular surveys of employers' opinions on the preparation of graduates for professional work
    - Developing specific recommendations for improving the learning process and methods for assessing learning outcomes

6. Supporting the development of teaching staff:
    - Initiation and organisation of training courses and workshops for lecturers, led by industry experts
    - Creation of experience exchange programmes between academic staff and company specialists
    - Recommend research topics and projects that can contribute to the development of teaching staff competencies

7. Promoting the direction of materials engineering:
    - Active participation in the organisation of events to promote the course of study, such as open days or education fairs

- Support initiatives to popularise knowledge of materials engineering among secondary school students
- Collaborate in the creation of attractive promotional and informational material about the course of study

8. Supporting the internationalisation of the study programme:

- Identification of cooperation opportunities with renowned foreign universities and companies
- Recommending the introduction of classes taught in foreign languages
- Actively support student exchange programmes and internships abroad

8.3. Assessment of Benefits and Challenges in the Functioning of the Advisory Board for the Materials Science Masters Programme

The effective functioning of the Materials Engineering Curriculum Council, and the consequent optimisation of the curriculum and its adaptation to the current needs of the labour market, brings a number of benefits to all parties involved. However, this requires commitment, openness to change and readiness for continuous improvement on the part of all stakeholders.

The following is a SWOT analysis for the initiative to establish an Advisory Board for the Materials Science Masters Programme:

Strengths:

- Increase the timeliness and relevance of the study programme to the needs of the labour market.
- Improving the quality of education by aligning curriculum content with industry requirements.
- Strengthening cooperation between the university and companies in the materials engineering industry.
- Possibility of organising internships and placements for students in partner companies.
- Increase graduates' chances of finding attractive employment after graduation.
- Supporting the development of teaching staff through training and placements in companies.
- Initiate joint research and development projects between the university and industry.

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Weaknesses:

- The need to commit additional resources (time, financial, human) to service the Council.
- Potential difficulties in gaining and maintaining industry involvement.
- Risk of divergence of interests between the university and business partners.
- Possible delays in implementing changes to the study programme due to university procedures.
- Limited flexibility to modify the study programme due to formal requirements.

Opportunities:

- Increasing the attractiveness of the university to potential students through an innovative study programme.
- Obtain additional funding for the development of teaching and research infrastructure.
- Establish long-term partnerships with leading companies in the materials engineering industry.
- Increase the university's visibility in the industrial and scientific community.
- Possibility to commercialise the results of joint R&D projects.
- Improving the competitiveness of graduates in the labour market through practical experience.

Threats:

- Changes in technological trends and labour market demands, requiring frequent updates to the study programme.
- Competition from other universities offering similar study programmes in collaboration with industry.
- Possible conflicts of interest between the university and business partners.
- Risk of industrial partners not fulfilling their declared commitments.
- Changes in higher education legislation that may hinder the functioning of the Council.
- Potential difficulties in attracting and retaining high quality teaching staff with the right skills.

The SWOT analysis for the initiative to set up a Consultative Council for the Degree Programme in Materials Science and Engineering indicates that this undertaking provides significant opportunities to increase the quality and attractiveness of the degree programme, better prepare graduates for professional employment and increase their competitiveness in the labour market. The initiative also carries development potential for the university itself, including the opportunity to attract additional funding, establish long-term partnerships with leading companies in the industry and increase prestige and recognition in the industrial and scientific community. However, the challenges and risks associated with the establishment and operation of the Consultative Council should not be underestimated, such

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as the need to commit additional resources, the potential divergence of interests between the university and business partners, the constraints imposed by university procedures or the risk of partners not fulfilling their commitments. Key to the success of the initiative will be ensuring an appropriate level of involvement from industry representatives, flexibility in adapting the study programme to the dynamically changing technological and market conditions, and ensuring that the high competence of the teaching staff is maintained.

9. Quality Policy: Design, Approval, Monitoring, Review, and Improvement of the Study Programme

In the face of a rapidly changing labour market and rapid technological advances, maintaining the relevance and high quality of the Materials Science Masters (MSM) degree programme requires constant monitoring and adaptation. Although the current version of the programme is the result of a multi-stage process of developing and adapting the educational content, the project partners are fully aware that its completion alone does not represent the end of the work on programme quality. On the contrary, they see it as a starting point for further activities to ensure that the MSM is continuously responsive to changing student needs, market requirements and the latest trends in materials science.

This is why the exchange of experiences has led to the development of assumptions for a comprehensive system of monitoring, reviewing and improving the programme, taking into account best practices in stakeholder cooperation, analysis of learning outcomes and implementation of modern teaching methods. The partners agreed that in a dynamic educational reality, it is essential that the programme not only meets current standards, but also flexibly adapts to future challenges.

The key elements of this system are outlined below, representing a set of good practices aimed at systematically improving the programme and ensuring its high quality and relevance to the real requirements of the labour market and students' expectations.

9.1. Elements of the Quality Assurance System of the Materials Science Masters (MSM) Programme:

1. Monitoring Learning Effectiveness

Monitoring the effectiveness of the achievement of learning outcomes in the MSM programme is a key element in ensuring the quality and currency of education. Systematic assessment of outcomes makes it possible not only to check whether students are achieving the intended outcomes, but also to identify areas requiring support or modification.

- **Monitoring of Learning Outcomes Verification:** The learning outcomes verification process includes analysis of the results of examinations, projects and final papers, as well as feedback collected from students and lecturers. Through regular analysis, curriculum content and teaching methods can be adjusted to better meet student needs and market standards.

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The project partners also recommend the organisation of workshops and meetings to discuss the results of the monitoring so that any discrepancies can be addressed on an ongoing basis.

- **Monitoring the Diploma Process:** The graduation process requires special attention, as the theses should not only meet the established learning outcomes, but also correspond to current industry trends. Annual reviews of diploma theses make it possible to verify their quality and compliance with the MSM programme, while meetings between academic staff and industry representatives allow for lessons to be learned and suggestions for improvement to be made.
- **Professional Practices:** Apprenticeships are an essential part of the MSM programme, enabling students to gain practical skills in a real work environment. Monitoring of apprenticeships, carried out in collaboration with external organisations, ensures they are in line with market needs. Placement supervisors monitor student progress and annual placement reports enable improvements to be made.

2. Cooperation with Internal and External Stakeholders

The high quality of the MSM programme requires collaboration with both internal and external stakeholders, such as employers, alumni and industry bodies. The constant exchange of information allows the programme to be adapted to market requirements and student needs.

- **Cooperation with the socio-economic environment:** The involvement of representatives of industry and public institutions makes it possible to adapt the programme content to the actual requirements of the labour market. The project partners recommend the organisation of regular meetings with employers and representatives of the science and technology sector to discuss the needs and challenges of the development of the materials industry on an ongoing basis.
- **Cyclical Meeting of the Teaching Staff:** Annual meetings of research and teaching staff allow for a direct exchange of experiences and comments on the implementation of the MSM programme. This allows for a better understanding of the challenges of teaching and improvements in teaching methods.
- **Meeting with Students in the Course:** The organisation of annual meetings with students enables their opinions and suggestions on the programme to be heard. Such consultations are an important part of the improvement system, as they allow the needs and expectations of students to be taken into account in the process of monitoring and adapting the programme.

3. Improving the Study Programme

- **Update programme content:** Establish a schedule for cyclical reviews and updates of programme content, taking into account stakeholder suggestions and the results of learning outcomes monitoring.
- **Implementation of modern teaching methods:** Expanding teaching methods to include digital learning tools and project-based methods to enhance students' acquisition of practical knowledge. Monitoring educational trends enables ongoing adaptation of the programme to innovations in science and technology, introducing new tools and techniques that support the effective acquisition of knowledge, skills and key competences in today's labour market.

4. Quality Assurance of Teaching Staff

The quality of the teaching staff is one of the key elements in ensuring a high level of education on the MSM course. Staff should combine both in-depth specialist knowledge and teaching skills that enable them to effectively transfer knowledge and engage students in the learning process. The project partners have developed measures to improve the competences of lecturers and to ensure that their qualifications meet changing educational and market requirements (see chapters: *Competences, experience, qualifications of teaching staff*, *Support of staff in the implementation of modern technologies in teaching*).

- **Evaluation Improving the Academic Didactics Process:** The didactic evaluation process of MSM staff includes regular surveys and analyses of the results conducted among students. The data enables the identification of strengths and areas in need of development , which allows for continuous improvement of the quality of education. In order to further improve the teaching competences of the staff, it is recommended to introduce improvement hospitalizations and to develop learning communities for mutual support and exchange of experiences in teaching methods.

5. Infrastructure and Learning Resources

High-quality teaching infrastructure and extensive library and information resources are essential for the effective delivery of the MSM programme.

- **Teaching and learning infrastructure:** the cyclical assessment of the technical condition of laboratories and teaching spaces allows the identification of areas in need of modernisation, enabling effective planning and implementation of improvements. An important element is the ongoing collaboration with teaching staff and students to gather their feedback on the quality and functionality of the infrastructure and educational resources. Regular investment in laboratories and teaching spaces is essential to ensure that students have access to the latest technology, which supports the development of their practical competences and prepares them for the modern professional environment.

- **Library, information and educational resources**: The systematic updating of library resources and digital educational materials is key to maintaining high quality education. This process should be based on analyses of learning trends and industry needs, allowing for the introduction of the latest publications and expanding access to specialised databases. This gives students access to up-to-date, valuable materials that support their development of knowledge and skills necessary for the labour market.

6. Supporting Students in the Learning Process

- **Support national and international mobility:** Provide opportunities for students to participate in foreign exchange programmes through financial and organisational support and the implementation of a full recognition system for learning outcomes gained abroad. Such activities enable students to gain valuable educational and professional experience, which enriches their competences and prepares them for the global labour market.
- **Motivating students**: Organising additional events such as workshops, seminars or industry competitions that motivate students to develop academically and professionally. These initiatives foster students' active involvement in the learning process, develop their practical skills and build their industry network.
- **Informing students about support:** Establish an information system that will provide students with up-to-date information on available forms of support, such as academic counselling, career development programmes, scholarships or mobility funding opportunities. This system will make it easier for students to access resources to support their development and help them to plan their career path in an informed manner.

10. Fostering Inclusion and Diversity in Materials Science Curriculum: International Laws, Strategies, and Best Practices

10.1. SECTION 1

10.1.1. International Laws for Creating an Inclusive Environment in Universities

Creating an inclusive environment in universities is regulated by several international documents and regulations that define the rights of people with disabilities and the obligations of states to ensure their equal opportunities in all spheres of life, including education. Here are some of the most important international instruments:

1. **UN Convention on the Rights of Persons with Disabilities (CRPD)**: This convention, adopted in 2006, establishes international standards for the protection of the rights of persons with disabilities, including the right to education without discrimination and ensuring accessibility of all aspects of the educational process.
2. **The UN Declaration on Human Rights (Universal Declaration of Human Rights)**: This basic document also guarantees the right to education without any form of discrimination.
3. **UN Convention on the Rights of the Child (CRC)** : It obliges member states to ensure the rights of every child, including children with disabilities, to education, as well as to the accessibility of educational institutions.
4. **UNESCO standards for inclusive education (UNESCO Standards he Inclusive Education)**: UNESCO has developed standards that promote inclusive education, particularly in universities, and call for equal opportunities for all students.
5. **European Convention for the Protection of Human Rights and Fundamental Freedoms (ECHR)**: This convention is also important for the protection of the rights of people with disabilities, particularly in the field of education.

These international documents call on member states to take concrete measures to ensure the accessibility of educational institutions for all students, including those with special needs due to disabilities. States are obliged to develop and implement policies that promote inclusive education and the creation of university environments that support the equality and comprehensive development of each student.

10.1.2. International Laws for Creating a Diverse Environment at the University

The creation of a diverse environment in universities is regulated by a number of international instruments and standards aimed at ensuring equal opportunities, compliance with the principles of non-discrimination and promotion of inclusion. Here are some of the most important international regulations in this area:

1. **UN Convention on Human Rights (Universal Declaration of Human Rights)**: This document, adopted by the UN General Assembly in 1948, defines basic human rights, including the right to education without any form of discrimination.
2. **UN Convention on the Rights of Persons with Disabilities (CRPD)** :
3. **European Convention on the Protection of Human Rights and Fundamental Freedoms (ECHR)**.
4. **UNESCO Declaration on Equality and Cultural Diversity (UNESCO Declaration he Cultural Diversity)**: This declaration calls for the promotion of diversity in all spheres of life, including education, and defines the role of universities in strengthening cultural diversity.
5. **UNESCO standards on the equality of foreign language education (UNESCO Standards he Language Rights)**: These standards emphasize the need to ensure equal conditions for students from different linguistic and cultural contexts.

These international documents establish standards and principles that contribute to the creation of a diverse and inclusive environment in universities. They call on states to adopt legislative, political and practical measures to ensure equal opportunities and compliance with the principles of justice in the field of education.

The Master's program in materials science attracts students due to high demand for specialists, competitive salaries, opportunities for innovative research, interdisciplinary approach, social and environmental impact, educational and scientific opportunities, as well as personal interest and passion for science. These factors together create attractive prospects for students who wish to contribute to the development of modern technology and science.

10.1.3. Inclusive Education in Materials Science

Information on how often people with disabilities choose to study materials science is not always readily available due to the lack of detailed statistics or research on this very issue. However, there are several key aspects that may influence the choice of disabled people to study in this field:

1. **Accessibility of infrastructure and equipment**: For disabled people, particularly those with physical limitations or other specific needs, it is important that universities have adequate infrastructure and accessible equipment for laboratory work and other practical tasks in materials science.
2. **Support and adaptive technologies**: It is important to have support from the university administration and specialized services for students with disabilities, as well as access to adaptive technologies that facilitate learning and completing academic tasks.
3. **Inclusive education policy**: Having an inclusive education policy that provides equal conditions for all students, regardless of their disability or other personal characteristics, can encourage disabled people to choose material science studies.
4. **Social support and inclusive culture**: It is also important to have social support among employees and the student body, which contributes to the creation of an inclusive culture in the university environment.

In general, the choice of studying materials science for people with disabilities may depend on many factors, including the availability of infrastructure, support for inclusive policies, and the personal interests and capabilities of the student.

10.1.4. Strategies for Attracting Inclusion and Diversity in Master's Programs in Materials Science

Universities are developing various strategies and creating special conditions to attract inclusion and diversity in master's programs in materials science. Here are some of them:

1. Recruitment and admission
   - **Targeted recruitment efforts**: Universities actively seek candidates from different socio-cultural, ethnic and geographic groups. This includes participation in international education fairs, webinars for potential applicants and expanding the recruiting geography.
   - **Expanded Access to Information**: Providing access to information about programs, scholarships, financial aid and support for students from diverse cultural and social backgrounds.
   - **Support for international students**: Creation of special programs for international students, including support for adaptation to the new environment and cultural context.

2. Financial support and scholarships
   - **Promoting diversity through scholarships** : Providing scholarships and financial support for students from diverse cultural, economic and geographic contexts, helping to reduce financial barriers to access to higher education.
3. Mentorship and support programs
   - **Mentoring support**: Introducing mentoring programs for new students, especially those who may need additional support adjusting to a new environment or academic program.
   - **Psychological support**: Providing access to psychological support and counseling for students from different cultures and backgrounds to help them successfully integrate into university life.
4. Education programs and cultural awareness
   - **Courses on inclusion and equality** : Organization of courses, seminars and working groups on issues of inclusion, equality and cultural awareness for students and university staff.
   - **Cultural Events:** Hosting cultural events that celebrate and expand understanding of differences and cultural traditions among the student community.
5. Flexibility in programs
   - **Individualized programs** : Providing opportunities for individual selection of programs or specializations that meet the interests and needs of students from different sociocultural and geographic backgrounds.
6. Creating a safe and supportive environment
   - **Safe environment**: Providing a safe and human rights-friendly environment where every student can feel free and supported.

Conclusion

Universities are making significant efforts to foster inclusion and diversity in materials science master's programs, which creates a conducive environment for the learning, development, and success of students from diverse sociocultural and geographic backgrounds.

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10.1.5. Requirements for Creating an Inclusive Environment in Universities

Creating an inclusive university environment includes various aspects that aim to ensure accessibility, equal opportunities and support for all students, faculty and staff. Here are the key requirements and aspects to consider:

1. **Physical environment and accessibility**: Universities must ensure physical accessibility to all premises and facilities for persons with various types of disabilities. This includes buildings, classrooms, laboratories, libraries, sports fields, etc. For example, the presence of ramps, elevators, accessible toilets, special equipment for the blind and visually impaired.
2. **Technological Accessibility**: Providing access to modern technologies and software that enable students with disabilities to learn effectively and compete with others. This can include e-books, screen readers, speech recognition programs, etc.
3. **Psychological and social support**: Universities should provide psychological support and counseling for students with disabilities, as well as create a positive atmosphere of tolerance and support among the student body and teaching staff.
4. **Adaptation of the learning process and assessment**: Development of individual learning and assessment plans for students with disabilities that take into account their needs and capabilities. This may include additional time for taking exams, adapting the assessment format, and more.
5. **Culture of Inclusion and Educational Initiatives**: Informational education programs for all members of the university community on the importance of inclusion, equal opportunities and non-discrimination. Regular training and seminars for staff and students.
6. **Participation and representation** : Involvement of student organizations and representation of students with disabilities in university administration, admissions committees and administrative decisions related to inclusion policies.

Therefore, the general approach to creating an inclusive environment in universities is that every student can feel important and provided with conditions for learning, development and participation in university life, regardless of their disability or other personal characteristics.

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10.1.6. The Rule of Inclusion and Diversity in Choosing a Profession in the Field of Materials Science

Thus, many countries and organizations have policies and initiatives aimed at promoting inclusion and diversity in career choices in materials science and other scientific disciplines. Here are some examples of such rules and initiatives:

1. **Educational programs and scholarships**: Many universities and research institutions offer programs and scholarships that support students from underrepresented groups. These can be women, national minorities, people with disabilities and other groups.
2. **Equal Opportunity Policy**: Many companies and research institutions have an equal opportunity policy that prohibits discrimination based on gender, race, national origin, religion, age, sexual orientation, and other characteristics.
3. **Professional organizations and associations**: There are professional organizations, such as the Materials Science Society (Materials Research Society) and the American Ceramic Society (American Ceramic Society) that have committees or special programs to support diversity and inclusion.
4. **Mentoring programs and internships**: Many institutions offer mentoring programs and internships for young scientists and engineers from underrepresented groups, helping them develop careers in materials science.
5. **Legislative Initiatives**: In some countries, there are legislative initiatives that require employers to adhere to certain inclusion and diversity standards. This may include quotas for hiring representatives of diverse groups or mandatory diversity reports in companies.

Such events help to create a more level playing field for all those who wish to work in the field of materials science and contribute to the development of a diverse and innovative scientific community.

10.1.7. Types of People with Disabilities Who Study and Work in the Field of Materials Science

A disabled person working in a laboratory may have different types of disabilities and use various adaptations for convenience and efficiency in work. Example:

1. **Musculoskeletal Disability**: This category may use special chairs or chairs with back support, as well as height-adjustable tables to ensure a comfortable position when working with equipment or specimens.
2. **Blind or partially sighted disabled people**: For them, sound indicators that help orient themselves in space, as well as special equipment for reading and analyzing data, are important.

3. **Hearing Impairment**: These people may use special devices to reproduce sound or communicate with colleagues.
4. **Disability with insufficient physical health**: They may use mobile chairs or other special devices to move around the laboratory.

Depending on the specific situation and type of disability, each disabled person may have unique needs and requirements that are important to consider in order to create an inclusive environment in the laboratory.

10.1.8. Requirements for the Equipment of Laboratories for the Blind

There are several important aspects to consider when equipping laboratories for the blind to ensure accessibility and safety for experiments and research. Here are the main requirements:

1. Braille interfaces and markers: Laboratory equipment should have Braille markings or other blind-accessible markers so that visually impaired people can easily navigate.
2. Sound indicators and warnings: Some devices may have sound indicators to help blind users understand the status and parameters of the devices.
3. Sensory and vibrational feedback: It is important to be able to receive sensory or vibrational feedback from devices that normally require visual control.
4. Specialized software: Laboratory equipment should be compatible with software that supports speech synthesis or other accessibility technologies.
5. Equipment for clear sound and communication: Special sound systems or audio interfaces may be required for effective communication between instructors and visually impaired students.
6. Safety: Ensuring safe access and use for blind persons, including protection against insensitivity to touch and appropriate safety instructions.

These requirements will help ensure that the laboratories are as accessible as possible to blind students and researchers, allowing them to learn science and conduct research on an equal footing with other participants.

Several possible scenarios that show the participation of disabled people in scientific research and experiments in the laboratory, regardless of their visual impairment.

These scenarios demonstrate that with the right equipment, support, and adaptations, blind individuals can actively participate in laboratory research and have similar opportunities for scientific work as their sighted counterparts.

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1. Experiment using sensory devices: A blind person can participate in research using special sensory devices or experimental setups that allow parameters to be measured through touch or sound signals.
2. Use of braille markers and labels.
3. Collaboration with an assistant or colleagues: Blind people can work with assistants or colleagues who help with setting up and correcting devices, measuring results, and interpreting data.
4. Use of sound indicators and software.
5. Safety and regular training: It is important to ensure that blind persons are fully aware of laboratory safety rules and receive regular training in the use of specialized equipment.

An example of interaction between a blind employee and his assistant to demonstrate inclusion and diversity.

A young man sits in the lab, his instructor standing nearby, helping to set up a special device. On the table in front of them are Braille labels with markings for each appliance. Posters with information written in Braille are hung on the walls. The man carefully listens to the instructor's explanation and adjusts the device using special software that generates sound signals to indicate the parameters of the experiment. There is concentration and cooperation around them, because they are working together on a scientific project.

This description shows how a blind person can actively participate in laboratory research, using specialized technologies and collaborating with instructors and colleagues to achieve common scientific goals.

10.1.9. Requirements for the Equipment of Laboratories for People with Locomotive Disabilities

The specific needs and capabilities of the target audience must be taken into account when equipping laboratories for people with musculoskeletal problems. Here are some important requirements:

1. Availability and ease of access:
   - Ramps and lifts: Provision of ramps or lifts to access laboratories in case they are at a high level.
   - Wide doors: Doors should be wide enough to accommodate all types of wheelchairs or mobility devices.
2. Adapted workplace:

   - Lifting tables .
   - Ample maneuvering space: Provision of sufficient space for maneuvering a wheelchair or other mobility devices.
3. Technical equipment:
   - Ergonomic devices: Use of ergonomic devices and tools with easy access to control buttons or knobs.
   - Voice control: Providing the ability to control equipment using voice commands for people with limited mobility.
4. Security and monitoring:
   - Alarm and protection: Availability of alarm and protection systems that allow prompt response to any dangerous situations or accidents.
   - Condition monitoring: The use of monitoring technologies that allow monitoring the condition of disabled persons in real time, for example, through wearable device systems.
5. Training and support:
   - Lighting and adapted instructions: Providing adequate lighting and adapted instructions for each type of equipment to ensure ease of use.

These requirements make it possible to create an environment that adheres to the principle of accessibility and provides equal opportunities for all users, including people with musculoskeletal problems.

10.1.10. Requirements for the Equipment of Laboratories for the Deaf

To ensure the effective work of deaf people in laboratories, their specific communication and safety needs must be taken into account. Here are the basic hardware requirements:

1. Visual signals and indication:
   - Light signals: The presence of light signals or indicators that show the status of devices or signal important events.
   - Special Markers: Using special markers or lighting to indicate safe areas or important instructions.
2. Remote communication technologies:
   - Video conferencing: The ability to use video conferencing for remote communication with specialized support services or colleagues.

- Text chats: Using text chats or special applications to exchange messages and documents.

3. Adapted equipment and interfaces:
    - Text-based interfaces: Using text-based interfaces and speech synthesis software to interact with laboratory equipment.
    - Ergonomic designs: Development of ergonomic solutions that ensure ease of use for deaf users, including the presence of accessible buttons and switches.
4. Safety and instructions:
    - Visual instructions .
    - Lighting .
5. Communication support:
    - Sound recordings .
6. Dedicated support services: Access to dedicated support services and consultants who can help resolve technical issues or provide the assistance you need.

These requirements make it possible to create an environment that takes into account the needs of deaf people and provides them with comfortable conditions for working in the laboratory, while maintaining a high level of safety and efficiency of scientific research.

10.1.11. Involvement of People with Disabilities in Dual Education in the Field of Materials Science

Involving people with disabilities in dual education in the field of materials science can be a difficult task due to the need for specialized support and adaptation of the educational process. However, this is possible using the following approaches:

1. **Preparatory courses and support** : Before starting dual education, disabled people can be offered specialized preparatory courses, where they can familiarize themselves with the main aspects of materials science and acquire the necessary skills before entering the enterprise.
2. **Individual approach to training**: It is important to adapt the training program and working conditions to the needs of a specific disabled person. This may include access to specialist equipment, technical support and adapted training methods.
3. **Partnership with enterprises and social organizations**: Involvement of industrial enterprises that have experience in working with the disabled can contribute to a more successful implementation of dual education. It may also include support from social organizations that specialize in supporting disabled people in vocational training.

4. **Career counselor advice and support**: Providing disabled people with access to career counselors or mentors who can help them understand opportunities in the field of materials science and support them in their studies and internships.
5. **Financial support and scholarships**: Providing access to financial support, such as scholarships or grants, can make dual education more accessible to people with disabilities by reducing financial barriers to entry.

These approaches help to create conditions for the successful involvement of disabled people in dual education in the field of materials science, contributing to their professional development and integration in the labor market.

10.2. SECTION 2

10.2.1. The Importance of an Inclusive Workplace in Materials Science

An inclusive workplace in materials science is important for a number of reasons that affect the quality of scientific research, technological progress and overall work efficiency. Here are some aspects that highlight the importance of inclusivity in this industry:

1. **Diversity of experience and perspectives**: An inclusive work environment in materials science promotes the involvement of professionals from diverse cultural, social and educational backgrounds. This promotes diversity of ideas, approaches and perspectives, which can be critical for innovative solutions and scientific discoveries.
2. **Complexity of research**: Materials science often requires an interdisciplinary approach to understand the properties and applications of materials in various fields, from electronics to medicine. The diversity of experience and knowledge brought by different employees allows for more comprehensive and in-depth research.
3. **Innovation and solving complex problems**: The development of new materials and technologies often requires a creative approach and the ability to think innovatively. An inclusive environment stimulates the exchange of ideas and promotes the emergence of new ideas and solutions for complex technical and scientific challenges.
4. **Empowering talent**: Providing equal opportunities for all employees, regardless of their personal characteristics, allows companies to attract and develop the best talent. This stimulates innovation and promotes the development of the creative potential of the entire team.
5. **Social responsibility and reputation**: Organizations that actively work to create an inclusive environment demonstrate their social responsibility to employees, customers and the public.

This can positively affect their reputation and contribute to the creation of a stable and successful brand.

6. Therefore, an inclusive workplace in materials science contributes not only to the individual development of employees, but also to the development of the organization as a whole, stimulating innovation and the achievement of new scientific and technological discoveries.

10.2.2. Problems Arising in Creating Inclusive Workplaces in Materials Science ?

Creating inclusive workplaces in materials science may involve some challenges and issues that require attention and resolution. Here are some of them:

1. **Technical infrastructure adaptations**: Materials science often requires specialized equipment and laboratory facilities. It is necessary to ensure the accessibility and adaptation of this equipment for workers with different types of disabilities, for example, due to physical limitations or the need for special interfaces.
2. **Organizational culture and support**: It is important to create an organizational culture that supports inclusiveness and understands the needs of diverse employees. This includes training staff on different types of disabilities, developing procedures and approaches to interacting with disabled people, and creating barrier-free communication tools.
3. **Adaptation of work processes**: Some processes in materials science can be physically or technically difficult for people with disabilities. For example, some research tasks may require prolonged standing or manipulation of heavy equipment. It is important to develop adaptive approaches and opportunities for such situations.
4. **Access to professional training and development** : Workers with disabilities in materials science must have access to the necessary professional training and development to support their professional growth and career development. This may include training in the use of new technologies or improving skills in specific research areas.
5. **Managing expectations and perceptions**: Some employees or managers may have a limited understanding or misperception of the abilities of people with disabilities. It is important to work on managing expectations and raising awareness about the potential of disabled people in materials science.
6. **Legislation and Regulation**: Legislation on non-discrimination and the protection of the rights of persons with disabilities is also an important aspect of creating an inclusive workplace.

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Companies must adhere to relevant norms and standards to ensure equal working conditions for all employees.

Creating inclusive workplaces in materials science requires a comprehensive approach and careful consideration of the needs of different workers. This allows not only to ensure equal conditions for everyone, but also stimulates innovation and development in this important scientific field.

10.2.3. Examples of Adaptations and Duties of People with Disabilities in the Field of Materials Science

People with various forms of disabilities can work in the field of materials science, if the working environment is adapted to their needs. Here are some disability categories and examples of accommodations that may be needed:

1. People with musculoskeletal disorders:
   - Examples of adaptations: height-adjustable tables, open space under the tables, easy access to devices and equipment, ramps, elevators.
   - Responsibilities: Analysis of materials, data processing, modeling, conducting experiments using special equipment.
2. People with visual impairments:
   - Examples of adaptations: Use of programs for reading the screen, Braille displays, voice assistants, high-contrast materials.
   - Responsibilities: Data analysis, modeling, programming, research work that does not require visual control.
3. People with hearing impairment:
   - Examples of adaptations: Use of video communication with subtitles, visual warning systems, induction loops for hearing aids.
   - Responsibilities: Analysis of materials, development of new materials, experimental work, cooperation with colleagues through written and visual communication.
4. People with impaired fine motor skills or limited hand capabilities:
   - Examples of adaptations: Use of specialized tools, devices with easy access, automated systems for conducting experiments.
   - Responsibilities: Data analysis, development of new materials, programming, research work.

5. People with chronic diseases or energy limitations:
    - Examples of adaptations: Flexible work schedule, possibility to work from home, ergonomic workplaces.
    - Responsibilities: Research work, data analysis, modeling, work with literature and documentation.

Provision of appropriate conditions and adaptations enables people with disabilities to work effectively in the field of materials science, to make a significant contribution to scientific research and development of new materials.

10.2.4. Productivity of People with Disabilities in the Field of Materials Science

The performance of people with disabilities in materials science can vary depending on a variety of factors, including the type and degree of disability, the availability of support and adaptive technology, and personal abilities and motivation. Some key aspects are:

1. **Infrastructure and technology support**: The availability of specialized equipment, adaptive technologies and support from university administration and colleagues can significantly increase the productivity of disabled people in scientific research and development.
2. **Education and training**: Access to quality education and specialized training programs can stimulate the development of individual abilities and the contribution of disabled people to science.
3. **Psychological support and motivation**: It is important to support psychological comfort and motivation, which can contribute to increasing the productivity of disabled people in professional activities.
4. **Promoting an inclusive culture**: Universities and research institutions that actively promote an inclusive culture and equal access to opportunities usually achieve better results in involving disabled people in research work.

In general, the productivity of people with disabilities in the field of materials science can be significant if favorable conditions are created for the development of their abilities and capabilities, and if their unique needs and perspectives are taken into account.

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10.2.5. Features of Employment of People with Disabilities in Various Industries: Employment of People with Disabilities in the Energy Industry

Professional employment of disabled people in the field of energy can vary depending on the specific country, legislation and company policy. However, there are general principles and requirements that are usually taken into account when recruiting disabled people in this field:

1. Discrimination and equal opportunities:
   - Companies must comply with legislation on non-discrimination and provision of equal opportunities for disabled persons in the field of work. This includes the right to work and protection from any form of discrimination based on disability.
2. Adapted working environment:
   - Workplaces must be adapted to ensure the convenience of disabled people. This may include the availability of special equipment, adaptation of workstations and approaches to work.
3. Physical capabilities:
   - Depending on the specific position, certain physical capabilities may be required. It is important that companies provide adequate conditions for the performance of work by disabled people, which may differ from the standard.
4. Technical skills:
   - Some positions may require specialized technical skills and knowledge that disabled people can acquire through training or company-provided training.
5. Support and social adaptation:
   - It is important that companies provide support to disabled people in the employment and support process, including opportunities to adapt working conditions and help in solving problems that arise in the workplace.
6. Health and safety:
   - Ensuring safe working conditions for the disabled, including taking into account their special needs and possible limitations.

These requirements contribute to the creation of an inclusive working environment in the field of energy, which promotes the professional and personal development of disabled people and supports their integration into the labor process.

10.2.6. Employment of Women with Disabilities in the Energy Sector

Professional employment disabled - women in sphere energy industry has your features and requirements which importantly consider for software their inclusions and successful implementation professional responsibilities. Here some key aspects :

1. Discrimination law and equal opportunities:
    - Companies must comply with non-discrimination legislation and ensure equal opportunities for all employees, including women with disabilities. This means that all candidates should have equal access to jobs and professional development, regardless of gender or disability.
2. Physical conditions and safety:
    - It is important that the workplace is adapted to ensure the convenience of women with disabilities, including the availability of special equipment or workstations. The needs in this regard may differ from the traditional standards for men.
3. Professional skills and training:
    - Companies should provide disabled women with opportunities to acquire the necessary vocational skills and training to successfully compete in the energy industry labor market.
4. Adaptation of work processes:
    - Taking into account the possible limitations of women with disabilities when organizing work processes and providing support for their successful work performance.
5. Social support and integration:
    - Providing support for women with disabilities in the employment process, including social integration and the opportunity to interact with colleagues and senior management.
6. Raising awareness and culture:
    - Organizations should work to raise awareness and culture among employees about the importance of inclusion and equal opportunities for all, including women with disabilities.

These requirements help to create a favorable environment for disabled women in the field of energy, which contributes to their successful professional development and integration into the working environment.

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10.2.7. Employment of People with Disabilities in the Aviation and Automobile Industry

Professional employment of disabled people in the aviation and automotive industries may vary depending on the specific type of disability and individual needs. Here are some general requirements and aspects to consider:

1. Discrimination and principles of equal opportunities:
   - Companies must comply with non-discrimination laws and provide equal opportunities for disabled people in the workplace.
2. Adapted working environment:
   - Workplaces must be adapted to ensure the convenience of disabled people, including the presence of special workstations or equipment.
3. Availability of education and training:
   - Companies must provide opportunities for disabled people to obtain the necessary training and skills to work in the aviation or automotive industry.
4. Physical capabilities:
   - Some positions may require certain physical abilities, so it is important that companies provide adequate conditions for the work of disabled people.
5. Technical skills:
   - Depending on the position, it may be important to have specialized technical skills and knowledge required in the aviation or automotive industry.
6. Support and adaptation:
   - It is important that companies provide support to disabled people in the employment process, including the possibility of adapting working conditions and assistance in solving problems that arise during the work process.

These requirements help ensure equal opportunities for people with disabilities in the aviation and automotive industries while maintaining a high level of professional competence and workplace safety.

10.2.8. General Requirements for the Equipment of Laboratories for People with Disabilities at Enterprises

Here are some basic requirements for disabled laboratory equipment to ensure a safe and comfortable working environment:

1. Availability of space:
   - Wide doorways (minimum 90 cm) for convenient passage of wheelchairs.

- Space for turning the cart (diameter 150 cm).
- Ramps with a slight slope and handrails.

2. Working places:
    - Height-adjustable laboratory tables and chairs.
    - Open space under the tables for convenient placement of a wheelchair.
3. Equipment and devices:
    - Devices with a low location or adjustable height.
    - Control of devices should be convenient for people with limited hand mobility.
    - All control elements should be located at a reachable height (90-120 cm).
4. Security:
    - Easy access to emergency exits and emergency equipment.
    - Fire alarm with visual and audio signals.
    - Easily accessible emergency shutdown buttons.
5. Storage:
    - Cabinets and shelves at an achievable height (not higher than 120 cm).
    - Use sliding or sliding doors for easy access.
6. Additional facilities:
    - Voice assistants or automation for equipment management.
    - Information panels with large font and high contrast.
7. Communications:
    - Use of accessible technologies for people with hearing and vision impairments.
    - Accessibility of Internet resources and software for people with disabilities.
    - Providing such conditions will contribute to the productive and safe work of people with disabilities in laboratory conditions.

10.3. SECTION 3

10.3.1. The Influence of War and Cataclysms on the Gender Distribution of Profession Choice in the Field of Materials Science

Wars and cataclysms can significantly affect the gender distribution of career choices in the field of materials science and other scientific disciplines. These impacts can be both negative and positive, depending on the specific context and measures taken by society to overcome the consequences of crisis situations. Below are some key aspects of this influence:

Negative influences

1. Destruction of educational infrastructure :
   - Destruction of schools and universities : Wars and natural disasters can lead to the destruction of educational institutions, making access to education difficult for all, but especially for girls, who may face additional social barriers.
   - Interruptions in education: Interruptions in education can prevent many students, especially girls, from returning to school.
2. Economic difficulties:
   - Declining family incomes : In times of economic instability, families may not be able to finance the education of their children, especially girls, who may be seen as less of a priority in this context.
   - Need for work: Young people may be forced to give up their studies in order to help their families financially.
3. Social barriers:
   - The rise of traditional gender roles: In crisis situations, societies may lean toward more traditional gender roles, limiting women's opportunities for professional development.

Positive influences

1. The need to involve all resources :
   - Expanding Roles for Women: During wars, when men may be involved in hostilities, women often take on non-traditional roles, including technical and scientific occupations. This can contribute to the growth of women's participation in materials science.
   - New opportunities for women : Crises can force society to rethink traditional gender roles and provide more opportunities for women in science and technology.
2. Post-war recovery and reforms :
   - Investment in education and science : Post-war recovery can include significant investment in education and science, creating new opportunities for all, including women.

- Social change : Crises can accelerate social change that supports gender equality, including supporting women in technical and scientific professions.

Examples from history

1. ***World War II**: During World War II, many women worked in factories and research laboratories, replacing men who were at the front. This provided the impetus for changing gender roles in the workforce.*
2. ***The collapse of the Soviet Union**: The economic crisis in the post-Soviet countries led to a decrease in the funding of scientific research, which particularly hit the female part of the scientific community, which had fewer resources to adapt to the new conditions.*

Strategies for mitigating negative impacts

1. Targeted support :
   - Scholarships and grants: Providing financial assistance to students from crisis regions, especially women, to continue their education.
   - Reintegration programs: Development of programs for the reintegration of students who were forced to interrupt their studies due to wars or cataclysms.
2. Reconstruction of educational infrastructure:
   - Investments in schools and universities: Reconstruction and modernization of educational institutions in post-crisis regions.
   - Distance learning: Development of distance learning programs that allow continuing education even in adverse conditions.
3. Support of gender equality:
   - Political and social initiatives: Implementation of policies that promote gender equality in access to education and professional development.
   - Awareness raising: Campaigns raising awareness of the importance of gender equality in science and technology.

Thus, while wars and natural disasters can pose significant challenges to the gender distribution of career choices, the right strategies and interventions can help mitigate their negative effects and promote greater inclusion and diversity in the field of materials science.

10.3.2. Global Practice of Involving Disabled War Veterans in the Profession in the Field of Materials Science

There are various initiatives and programs in the world to attract disabled war veterans to professions in the field of materials science. Here are some examples:

4. **USA**: Program " Veterans in Piping » in collaboration with United Association (UA) helps veterans get vocational training in various technical specialties, including work with metals and materials. This program provides veterans with skills and knowledge that they can apply in the manufacturing field.
5. **Great Britain**: Program " Defence Transition Services » facilitates civilian retraining for veterans, including training in engineering and materials science. This includes training and internship opportunities in various high-tech sectors.
6. **Canada**: Program " Helmets that Hardhats Canada » helps veterans enter construction and engineering professions, including materials science. It provides support in education, preparation for work and placement in the labor market.
7. **Australia**: Program " Soldier On » offers support to veterans for education and vocational training in high-tech fields that include materials engineering and technology.

These examples demonstrate how different countries are developing initiatives to support veterans in their professional reorientation and retraining in the field of materials science and other technical specialties. These programs provide not only training, but also support in finding a job and integrating into civilian life, promoting social inclusion and professional development of veterans.

10.3.3. Recruitment of People with Disabilities in Sub-Employment Due to the War in Ukraine

Attracting disabled people to employment at enterprises during the war in Ukraine is an important humanitarian and social initiative. The war leads to a significant increase in the number of people with physical limitations who need support and opportunities for full social integration. Here are some important aspects of the inclusion of disabled people in wartime enterprises:

1. **Social support for the disabled**: It is important to ensure the access of the disabled to social programs and support that will help them recover and adapt to new living and working conditions.
2. **Adaptation of workplaces**: Enterprises must be ready to adapt workplaces for disabled people, providing the necessary conditions for their comfort and safety. This may include the installation of special equipment, adapted furniture and accessible infrastructure solutions.

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3. **Inclusive workplace culture**: It is important to create a culture of tolerance and respect for all employees, regardless of their physical or social situation. An inclusive environment will help preserve team spirit and support the psychological comfort of disabled people.
4. **Support from the state and international organizations**: It is important that state and international organizations provide support in the form of financial resources, advice and training for businesses to disabled people in order to facilitate their successful integration into the labor market.

The general approach should be aimed at creating conditions that allow disabled people to feel useful members of society and ensure their access to equal opportunities in the field of work during military conflicts.

Unfortunately, accurate statistical data on the increase in the number of disabled people due to the war in Ukraine are complex and unavailable due to many factors, including the lack of a centralized system of registration and accounting of disabled people due to the war. Military actions can lead to a significant increase in the number of wounded, disabled, and people with other physical and mental limitations. One of the main sources of information are reports and studies of public organizations that work in the field of protecting the rights of people with disabilities and supporting veterans. These organizations monitor and analyze the socio-economic consequences of the war on the population, in particular on the disabled. The common effects of war include physical injuries, amputations, brain injuries, mental and emotional traumas that can significantly affect people's lives and ability to work. It is important to support this category of the population, as well as ensure their rights to equality in access to jobs, health care and other social services.

Ukraine, like many other countries, experiences difficulties in collecting and systematizing such information due to the difficult conditions of military operations and the distribution of resources for social and medical support of the disabled.

10.4. SECTION 4

10.4.1. Gender Influence in Choosing a Profession in the Field of Materials Science

Gender influence when choosing a profession in the field of materials science, as in many other technical and scientific fields, can be significant. There are several factors that influence this choice and cause gender imbalance:

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Social and cultural factors

1. **Stereotypes** : Social stereotypes that scientific and technical professions are more suitable for men can discourage girls from choosing such careers.
2. **Role models**: The lack of women in prominent positions in materials science can lead to girls not seeing themselves in these roles.
3. **Family expectations**: In some cultures, family expectations can influence career choices, favoring traditional female roles.

Educational factors

1. **Access to education**: In some regions, girls may have less access to quality education in science and technology.
2. **Support at school and university**: Teachers and professors may not always support girls in choosing a career in science and technology.

Professional factors

1. **Discrimination and prejudice** : Women can face discrimination and prejudice both during their studies and in the workplace.
2. **Career opportunities**: Women may have fewer opportunities for professional growth and career advancement.

Initiatives to improve the situation

1. **Mentoring and support**: Establishing mentoring programs where experienced scientists help young women develop careers in materials science.
2. **Educational programs and activities**: Conducting seminars, workshops and programs that popularize scientific and technical disciplines among girls.
3. **Scholarships and grants**: Provision of special scholarships and grants for girls and women who wish to study materials science.
4. **Policy of equal opportunities**: Implementation and observance of the policy of equal opportunities in scientific institutions and enterprises.

Thanks to such initiatives, the situation is gradually changing, and more and more women are choosing careers in materials science and other technical fields.

10.4.2. Choice of Women's Education in Materials Science

Statistics on the frequency of women choosing to study materials science may vary depending on the country, region and specific university. However, there are a few general trends:

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1. **Growing interest**: In recent decades, there has been an increase in interest among women in science and technology majors, including materials science. This is due to changes in public perception and opportunities for women in the scientific field.
2. **Support programs**: Many universities and scientific organizations are actively working to attract and support women in STEM fields (science, technology, engineering, mathematics), including materials science. This includes scholarships, mentoring support and specialized programs for female students.
3. **Research activity**: Women are increasingly noted in scientific research and development in the field of materials science, which indicates the growing role of women in this field.
4. **Specialized initiatives**: Universities and research institutions are actively developing initiatives to attract women to STEM professions, including materials science, through special events, seminars and conferences.

Considering these factors, it can be assumed that the interest of women in materials science is gradually increasing, but the specific numbers may vary depending on the specific country and the conditions of the university environment.

10.4.3. Implementation of Diversity in Companies in the Materials Industry

The implementation of diversity in materials science enterprises has several key important aspects:

1. **Innovation and creativity**: A diverse work environment promotes a mix of different experiences, approaches and perspectives, which stimulates innovation and creativity. Different perspectives and unique experiences of employees can contribute to the development of new ideas and solving complex tasks in the field of materials science.
2. **Increased competitiveness**: A diverse team is better able to understand the needs of different market segments and customers. This allows enterprises to adapt to changes in market requirements and compete effectively.
3. **Reputation and Brand**: Embracing diversity reflects a company's social responsibility, which can positively impact its reputation among consumers, investors, and potential employees.
4. **Legal requirements and ethics**: In many countries, there are laws and standards that govern the implementation of diversity policies and non-discriminatory practices in the workplace. Compliance with these norms is not only ethical, but also legally binding.
5. **Increasing talent engagement**: Diversity in the workplace helps attract talented employees from different cultures, professional areas and life experiences, which enriches the team and strengthens its creative potential.

In general, the implementation of diversity in materials science enterprises is an important element of the development strategy that contributes to sustainable success, innovation and high competitiveness in the global market environment.

10.4.4. Implementation of Inclusion in Companies in the Materials Industry

The implementation of inclusion in materials science enterprises is critically important for several reasons:

Diversity and creativity: An inclusive environment fosters the attraction of diverse talent and perspectives, which stimulates creativity and innovation. People with different life experiences and views can bring innovative ideas and approaches to solving complex problems in materials science.

Market Competitiveness : A diverse team can better understand the needs of different market segments and ensure the production of products that meet diverse customer requirements.

Social responsibility : Implementation of inclusive practices demonstrates the company's social responsibility towards employees, customers and society, which can positively affect reputation and relations with stakeholders.

Legal requirement and ethics : In many countries, there are legal norms that require the implementation of inclusion policies in the workplace to ensure equal working conditions and prevent discrimination.

Attracting talent : An inclusive environment attracts talented professionals from different cultures, specialties and life experiences, which enriches the team and contributes to the innovative development of the enterprise.

All these aspects emphasize the importance of inclusion in materials science enterprises as a strategic direction to achieve success, sustainability and competitiveness in the global market environment.

10.4.5. The Principle of Non-Discrimination and Protection of Employment Rights for People with Disabilities at a Materials Science Enterprise

Legislation in many countries establishes the principle of non-discrimination and protection of the rights of disabled people for employment. Thus, enterprises are obliged to consider candidates from among the disabled on an equal footing with other employees.

However, the obligation to employ disabled people depends on the specific legislation of the country, the field of activity of the enterprise, as well as the availability of suitable vacancies and possibilities of adaptation of workplaces.

Here are some key points:

1. **Anti-discrimination laws**: Many countries have laws that prohibit discrimination on the basis of disability in employment. This means that businesses cannot refuse to accept candidates just because of their disability.
2. **Obligation to consider applications**: Companies are obliged to consider the applications of disabled people on an equal basis with other candidates, if they meet the requirements of the vacancy and are able to perform the duties of the job with the necessary adaptations.
3. **Adaptability of workplaces**: Businesses can consider adapting workplaces for the needs of people with disabilities to ensure they can work effectively.
4. **Specialized support**: Some states provide businesses with financial support or other assistance to attract disabled people to employment.

Taking into account these aspects, enterprises can and should actively consider the possibility of employing disabled people, ensuring compliance with legal requirements and promoting the social inclusion of disabled people in the labor market.

10.5. SECTION 5

10.5.1. Conclusions and Recommendations

When creating a master's program in materials science with inclusion and diversity in mind, it is important to consider several key aspects. Here are some recommendations:

1. Development of various educational programs
   - Flexibility in choosing specializations : Ensuring that students can choose individual learning trajectories that take into account their interests and academic needs.
   - Wide range of disciplines : Inclusion in the program of various courses on various aspects of materials science, corresponding to modern trends and needs of industry.
2. Propaganda and recruiting
   - Active recruitment of students from different socio-cultural and geographical groups: Involvement of students from different countries and cultural environments to enrich the academic experience and cultural exchange.
   - Scholarship and Support Programs: Development of scholarship and financial support programs that reduce financial barriers to admission and study at a university institution.

3. Cultural inclusion and support
   - Cultural environment and support : Creating a friendly and safe cultural environment that supports the integration of students from different cultures and backgrounds.
   - Mentoring program: Implementation of mentoring programs to support students with different cultural and professional backgrounds.
4. Flexibility in educational approaches
   - Active use of diverse learning and assessment methods : Consideration of different learning styles and interactive methods to ensure accessibility of materials and success for all students.
5. International cooperation
   - Partnerships with international universities and exchange programs : Promoting opportunities for international exchanges and joint research projects that promote cultural exchange and mutual understanding.

These recommendations will help create a master's program in materials science that promotes inclusion and diversity, creating conditions for the success and development of all students, regardless of their cultural and social background.

10.5.2. Advantages of a Manufacturing-Oriented Master's Program in Materials Science with Inclusion and Diversity

A manufacturing-oriented materials science master's program with an emphasis on inclusion and diversity has several significant advantages:

1. **Inclusive learning and development**: The program promotes an inclusive environment where all students, regardless of their characteristics, feel welcome. This includes creating accessible academic materials, adapting learning environments and supporting different learning styles.
2. **Diversification of research potential**: The involvement of students from different cultural, ethnic and social backgrounds contributes to the diversification of approaches to scientific research and innovation in materials production.
3. **Promoting Equal Opportunity**: The program helps create the conditions for success for every student, regardless of their individual limitations or needs. This may include adapting laboratory work, working conditions and technical facilities for optimal teaching and research.
4. **Enhancement of cultural competence**: Interaction with different cultures and viewpoints contributes to the development of cultural competence in students, which is an important aspect in the globalized world of production.

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5. **Enrichment of the analytical approach**: Participation in cross-cultural communication and cooperation with different social groups can contribute to the expansion of analytical skills and perception of complex problems in the production of materials.
6. **Social responsibility and ethics**: The program can focus on social responsibility and ethics in production, in particular on ensuring an inclusive and safe environment for all workers in industrial settings.

These advantages make the manufacturing-oriented materials science master's program not only an educational departmental standard, but also a platform for building a culture of inclusion and diversity in the scientific and industrial community.

10.5.3. Recommendations for Improving the Master's Program in Manufacturing Materials Science with Inclusion and Diversity

The following recommendations can be considered to improve a manufacturing-oriented materials science MSc program with a focus on engaging inclusion and diversity:

1. Creating an inclusive atmosphere:
   - Ensure availability of information about the program and conditions of admission for students with different needs.
   - Embed a policy of inclusion and equal opportunity in all aspects of the program, including teaching, research and administrative procedures.
2. Expanding global presence:
   - Attract students from different countries and cultures to the program through active international recruitment and facilitate their integration into the academic environment.
3. Adaptation of training programs:
   - Develop flexibility in programs of study to accommodate the individual needs and interests of students with diverse professional and personal backgrounds.
4. Development of intercultural competence:
   - Provide educational programs that promote the development of intercultural sensitivity and mutual understanding among students and teachers.
5. Stimulation of research activity:
   - Support research projects that explore issues related to inclusion and diversity in materials production.

6. Career development support:
   - Development of career preparation programs that take into account the specifics of the labor market for graduates from inclusive groups and diverse cultural backgrounds.
7. Effective use of technologies:
   - Providing access to modern learning technologies and adaptive technologies for students with disabilities.
8. Monitoring and evaluation:
   - Continuous monitoring of the effectiveness of inclusive initiatives and implementation of corrective measures to improve the program.

These guidelines will help strengthen inclusivity and diversity in the manufacturing-oriented materials science master's program and provide students with an optimal learning environment for their academic and professional development.

10.5.4. Involving Inclusion and Diversity in Choosing a Profession in the Field of Materials Science

Attracting inclusion and diversity to career choices in materials science requires a comprehensive approach that spans multiple levels, from educational initiatives to policy and organizational change. Here are some key steps that can help you achieve this goal:

Educational initiatives

1. Early involvement :
   - Programs for schoolchildren : Organization of specialized programs, workshops and summer camps for schoolchildren to interest them in materials science from an early age.
   - Role models: Engaging successful women and representatives of other underrepresented groups as speakers and mentors.
2. Scholarships and financial support:
   - Scholarships: Providing scholarships for students from underrepresented groups to study in the field of materials science.
   - Financial Aid: Financial aid programs to cover the cost of tuition, textbooks, and laboratory supplies.

3. Educational resources and support:
    - Tutoring: Tutoring programs where older students or faculty help younger students adjust and succeed in their studies.
    - Career Centers: Creation of career centers that specialize in helping students from underrepresented groups.

Political and organizational initiatives

1. Policy of equal opportunities :
    - Anti-discrimination laws: Enact and enforce laws that prohibit discrimination on the basis of sex, race, nationality, and other characteristics.
    - Monitoring and reporting: Regular monitoring and reporting on the level of diversity and inclusion in educational institutions and businesses.
2. Organizational cultures and practices:
    - Inclusive culture: Promoting the creation of an inclusive culture in educational institutions and workplaces.
    - Diversity trainings: Conducting diversity and inclusion trainings and seminars for teachers, researchers and company employees.

Promotional events and campaigns

1. Popularization of the profession :
    - **Mass Media and Social Media** : Using mass media and social media to promote materials science and highlight the importance of diversity in the field.
    - **Success stories**: Showing real success stories of women and representatives of other underrepresented groups in materials science.
2. Partnerships and collaborations:
    - **Cooperation with public organizations** : Cooperation with public organizations dealing with issues of diversity and inclusion.
    - **Industry Partnerships**: Partnerships with companies and industry associations to create internship and employment programs for diverse groups.

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Research support

1. Grants and funding :
    - **Targeted Grants**: Providing targeted grants for research conducted by representatives of underrepresented groups or that address diversity issues in materials science.
2. Conferences and seminars:
    - **Inclusive Events** : Hosting conferences and workshops that specifically focus on issues of diversity and inclusion in science and technology.

Thanks to a comprehensive approach, it is possible to significantly increase the level of inclusion and diversity in career choices in the field of materials science, which will contribute to a more innovative and productive scientific community

10.5.5. Using Tools to Measure Progress in the Area of the Inclusive Labor Market

A variety of tools and approaches can be used to measure progress towards an inclusive labor market. Here are some key tools:

1. Index of disability equality on the labor market: Development of indices or evaluation methods measuring the level of inclusion in the labor market. This may include indicators of accessibility for different social groups, the degree of discrimination, transparency of information about vacancies and opportunities for career growth.
2. Analysis of the level of employment: Measurement of the share of different social groups in employment in various industries and professions. This allows you to assess how diverse and inclusive the labor market is in a specific region or sector.
3. Assessment of income level: Analysis of incomes of different groups in the labor market. This is important because an inclusive labor market must provide equal opportunities for all its participants to earn a sufficient income.
4. Monitoring of working conditions: Assessment of working conditions, including access to safe and healthy working conditions, adaptability of workplaces for people with disabilities and other aspects affecting inclusivity.
5. Assessment of the availability of vocational training and support: Measuring the availability and effectiveness of vocational training, rehabilitation and support programs for people with special needs or other social groups.

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6. Social survey and reports: Collection of feedback and data from various stakeholders (employers, employees, public organizations, etc.) regarding the level of inclusion in the labor market and implementation of measures to improve this situation.

These tools make it possible to make an objective assessment of the inclusiveness of the labor market and to determine directions for further actions to improve the situation in this area.

In particular, we focus on the Index of Equality of the Disabled (Disability Equality Index, DEI), which is a tool used to assess and determine the level of suitability of companies to work with people with disabilities and their equal opportunities initiatives. This index assesses the level of openness and inclusion in the field of employment for persons with disabilities. The DEI evaluates companies in several key categories, including hiring policies, workplace adaptation, web accessibility, educational initiatives, and inclusion of people with disabilities in corporate cultures. This index is an important tool for measuring progress in the area of an inclusive labor market and promoting a more equal environment for all workers. Questionnaire of the Disability Equality Index (Disability Equality Index, DEI) includes a number of questions evaluating companies' practices regarding inclusion and support of persons with disabilities. Here are some typical questions, the answers to which will increase the index of inclusion and diversity in companies and universities:

1. Policy and management:
    - Does the company have an equal opportunities policy for persons with disabilities?
    - Does the company have high-level managers responsible for disability inclusion?
2. Recruitment and development:
    - What hiring and retention programs for employees with disabilities exist in your company?
    - Are there training events and seminars on inclusive culture and accessibility?
3. Justification at the workplace:
    - Does your company have a workplace adaptation policy for people with disabilities?
    - Are technical facilities and infrastructure accessible to all employees, including those with disabilities?
4. Availability of information and communications:
    - Does the company's website meet accessibility requirements for people with different types of disabilities?
    - Are there policies regarding the availability of internal documents and materials for all employees?
5. Strategies and recommendations:

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- What measures does the company take to eliminate barriers in interpersonal communication and communication?
- Are there special programs of adapted technologies to support disabled people at work?

These questions help to assess the level of inclusion and preparedness of companies to work with the disabled and form the basis for the rating within the Disability Equality Index.

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11. Support for staff in the implementation of modern technology in teaching

Supporting academic staff in the implementation of modern technologies and didactic methods in the teaching of materials engineering is key to ensuring high quality education and preparing graduates for the challenges of today's labour market. This chapter presents a collection of good practices developed during the Materials Science Masters project to support academic staff in this regard.

The presented practices cover a wide range of activities, such as the organisation of international seminars integrating the perspectives of different stakeholders, study visits to foreign partner universities and industry enterprises, as well as specialised workshops improving the teaching competences of the staff. Key aspects include knowledge transfer, skills development, strengthening cooperation with the socio-economic environment and shaping future competences in students.

The presented good practices are universal and can be adapted by different universities educating in material engineering. Their implementation should be an ongoing process, based on regular evaluation of effects and adaptation of activities to changing needs.

1. Good practice: International seminar integrating stakeholder perspectives in improving the materials engineering curriculum
2. Good practice: Study visits of academic teachers to partner universities abroad
3. Good practice: A mentoring system based on the experience of study visits
4. Good practice: "Bridges of Knowledge" - Study visits of academic teachers to companies in the materials engineering industry
5. Good practice: "Innovative Hybrids" - blended-learning workshop for academics on materials testing methods
6. Good practice: "Employability Skills" workshop for teachers of materials engineering
7. Good practice: Improvement workshop on the formulation of learning outcomes
8. Good practice: 'AI-Buzz' - a workshop for academics on teaching the use of AI in brainstorming

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11.1. Good Practice: International Seminar Integrating Stakeholder Perspectives in Improving the Materials Engineering Curriculum

Practice Description:

The organisation of an international teaching seminar that aims to bring together and integrate different perspectives on materials engineering education. A key aspect of the seminar is to bring together representatives from four main stakeholder groups: academic staff, accrediting bodies, industry and the socio-economic environment.

Objective:

The aim of the internship is to gain a comprehensive view of the materials engineering education process, to identify areas for improvement and to develop specific recommendations for improving the study programme.

Methodology:

1. Preparation: Invite representative representatives of each stakeholder group.
2. Structure of the seminar: Divide the seminar into four main sessions, each dedicated to the perspective of one stakeholder group.
3. Presentations: Each group presented its approach to education, expectations and challenges.
4. Discussions: Following the presentations, discussion sessions were organised to allow for the exchange of views and the development of common conclusions.
5. Summary: Development of a list of recommendations for implementation in the study programme.

Results:

- Gain a multi-dimensional view of materials engineering education.
- Identification of gaps between the expectations of different stakeholders and the current study programme.
- Develop concrete proposals for changes to the programme, taking into account the needs of all groups.
- Establish lasting relationships between the university and representatives of industry and other sectors.

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Conclusions:

Practice has been effective in identifying areas for improvement in the study programme. The integration of different perspectives has helped to create an education programme that is more comprehensive and responsive to real needs.

Recommendations:

1. Organise similar seminars on a regular basis (e.g. every year or every two years) in order to continuously improve the study programme.
2. Expanding the range of participants to include international representatives.
3. Implementation of the developed recommendations and monitoring of their effects.
4. Using the seminar as a platform to establish long-term collaborations between the university and industry and other sectors.

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11.2. Good Practice: Study Visits of Academic Staff to Foreign Partner Universities

Practice Description: Organisation of study visits for academic teachers to foreign partner universities specialising in materials engineering. This practice enables direct exchange of experience, observation of innovative teaching methods and the establishment of international academic cooperation.

Aim: The aim of the internship is to improve the teaching competence of teachers, to internationalise the study programme and to implement international best practice in the education of materials engineers.

Methodology:

1. Preparation: Selection of partner universities and establishment of cooperation.
2. Planning: Development of a schedule and programme for study visits.
3. Implementation: Conduct visits including:
    - Observation of classes
    - Methodological workshops
    - Meetings with academic staff
    - Familiarisation with teaching and research facilities
4. Evaluation: Collection of feedback from participants.
5. Implementation: Implementation of lessons learned at home university.

Results:

- Expand knowledge of international trends in materials engineering teaching.
- Gain practical skills in innovative teaching methods.
- Establish lasting relationships with foreign academic centres.
- Increased linguistic and intercultural competence of staff.

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Conclusions:

Study visits have proven to be an effective tool for the development of academic staff and the internationalisation of the study programme. Direct contact with foreign practitioners inspires teaching innovations.

Recommendations:

1. Organise study visits on a regular basis (e.g. once a year for a selected group of teachers).
2. Rotation of participants to allow a wide range of staff to participate.
3. Creating a platform to share lessons learned with the entire academic community.
4. Initiating joint teaching and research projects with the universities visited.
5. Pursue an increase in the number of partner universities and geographical diversification to ensure diversity of experience.
6. Implement a mentoring system in which visit participants share the knowledge they have gained with other members of staff.

This practice will contribute to the continuous improvement of the quality of materials engineering education at our university, ensuring that the curriculum remains up to date with global trends and best practices in engineering education.

11.3. Good Practice: A Mentoring System Based on the Experience of Study Visits

Practice Description: Implement a comprehensive mentoring system in which academic staff who have participated in study visits to foreign partner universities act as mentors for other members of the teaching staff. This system is designed to effectively disseminate the knowledge, skills and experiences gained across the academic community.

Aim: The aim of the placement is to maximise the benefits of the study visits by systematically sharing the knowledge gained, promoting innovative teaching methods and supporting the professional development of academic staff in the area of materials engineering.

Methodology:

1. Organisation: Establish a team to coordinate the mentoring programme.
2. Recruitment: Selection of mentors from among study visit participants and mentees from the academic staff.
3. Training: Preparing mentors for their role.
4. Pairing: Connecting mentors with mentees based on areas of expertise and development needs.
5. Implementation: Conduct regular mentoring sessions, including:

    - Individual mentor-mentee meetings
    - Group workshops
    - Class observation and feedback
    - Support for the implementation of new teaching methods

6. Monitoring: Regular evaluation of the progress and effectiveness of the programme.
7. Evaluation: Collecting feedback from participants and analysing the impact on the quality of education.

Results:

- Wider dissemination of knowledge and good practices gained during study visits.
- Improving the teaching competence of all academic staff.
- Create a culture of continuous improvement and mutual learning.
- Increasing innovation in materials engineering teaching methods.
- Strengthening staff integration and networking within the university.

Conclusions:

The mentoring system has proven to be an effective tool for multiplying the benefits of study visits. It allows for the effective transfer of knowledge and skills within the university, contributing to an overall improvement in the quality of education.

Recommendations:

1. Provide institutional support for the mentoring programme.
2. Regularly update the mentor pool with new study visit participants.
3. Creating an online platform for sharing materials and experiences.
4. Organise regular events to integrate programme participants.
5. Include participation in the mentoring programme in staff appraisal and career progression pathway.
6. Expanding the programme to include inter-university mentoring, involving staff from partner universities abroad.

This placement, combined with study visits, will create a comprehensive system of academic staff development, contributing to the continuous improvement of the quality of materials engineering education and enhancing the international competitiveness of our university.

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11.4. Good Practice: 'Bridges of Knowledge: Study Visits of Academic Teachers to Companies in the Materials Engineering Industry".

Practice Description: Organisation of regular study visits for academic staff to leading companies in the materials engineering industry. This internship enables academic staff to come into direct contact with industrial realities, to learn about the latest manufacturing technologies and processes and to understand current labour market needs.

Aim: The aim of the apprenticeship is to strengthen cooperation between academia and industry, to update teachers' practical knowledge and to adapt the education programme to the real needs of the labour market in the field of materials engineering.

Methodology:

1. Preparation: Establish cooperation with key industry companies.
2. Planning: Development of a schedule and programme for study visits.
3. Implementation: Conduct visits including:
    - Business and technology presentations
    - Observation of production processes
    - Workshop with R&D staff
    - Discussions on employers' expectations of graduates
4. Evaluation: Collection of feedback from participants and companies.
5. Implementation: Implementation of lessons learned in the education programme.

Results:

- Updating the practical knowledge of university teachers.
- Better understanding of current industry trends and challenges.
- Establish lasting relationships with businesses.
- Identification of areas of the study programme requiring adaptation to market needs.

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Conclusions:

Industrial study visits are an effective tool in building a bridge between theory and practice. Direct contact with industrial realities inspires the introduction of practical elements into the curriculum.

Recommendations:

1. Organise study visits at least once a semester for different groups of teachers.
2. Rotation of businesses visited to ensure diversity of experience.
3. Create visit reports and share lessons learned with the entire academic community.
4. Initiating joint research and development projects with the companies visited.
5. Creation of a platform for the exchange of experiences, where participants of the visits will be able to share the knowledge gained with other members of staff

This practice will contribute to the continuous improvement of the quality of education by ensuring that the study programme remains relevant and meets the real needs of industry. This will ensure that graduates are better prepared for professional challenges and more competitive in the labour market.

11.5. Good Practice: 'Innovative Hybrids: a Blended-Learning Workshop for Academic Teachers in Materials Research Methods'.

Practice Description: Organisation of specialised workshops for academic teachers, focusing on the implementation of blended-learning methods in the teaching of materials engineering, with a particular focus on materials testing methods. The workshop combines elements of face-to-face and online teaching, demonstrating the practical application of this methodology.

Aim: The aim of the internship is to improve the competence of academic staff in the use of blended-learning tools and methods to teach complex materials research topics more effectively, combining theory and laboratory practice in a hybrid environment.

Methodology:

1. Theoretical presentation

- Introduction to the concept of blended-learning and its application in academic teaching
- Discuss the benefits of combining theory and laboratory practice in a hybrid environment
- Presentation of good practice examples and case studies of the use of blended-learning in materials science

2. Stationary phase

- Practical workshops on the use of hybrid learning tools (e.g. e-learning platforms, video conferencing tools, virtual labs)
- Participant-led blended-learning simulations of materials testing methods
- Discussion and feedback on the simulations carried out, discussion on possible improvements
- Working in groups to design their own blended-learning modules tailored to courses in materials research

3. Implementation phase

- Presentation of prepared modules to the group, peer review and feedback
- One-to-one consultations with trainers to improve the developed modules
- Development of a plan to implement the designed modules in the participants' teaching practice

4. Evaluation

- Evaluation questionnaire to assess the usefulness and effectiveness of the various elements of the practice
- Concluding discussion, sharing impressions and plans to implement blended-learning in own teaching practice
- Development of a report with recommendations for further development of staff competencies in hybrid teaching

Results:

- Increasing teachers' competence in blended-learning
- Development of innovative teaching modules for materials testing methods
- Improving the quality and effectiveness of teaching complex technical subjects
- Increase student engagement through interactive forms of learning

Conclusions:

Workshops are an effective tool in developing teachers' blended-learning skills. The approach works particularly well in teaching materials testing methods, where a combination of theory and laboratory practice is crucial.

Recommendations:

1. Organising workshops on a regular basis (e.g. once a semester) with different themes
2. Creation of a repository of developed blended-learning materials and modules
3. Encourage peer observation of activities and sharing of good practice
4. Monitoring the effects of implementing blended-learning in teaching materials testing methods
5. Conduct a long-term study of the impact of blended-learning on student learning outcomes in materials testing methods.

This practice will contribute to the modernisation of teaching methods, making materials engineering education more attractive and effective. As a result, students will be better prepared to work with modern research technologies, and teachers will gain new tools to impart complex technical knowledge.

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11.6. Good Practice: 'Employability Skills Workshop for Teachers of Materials Engineering'.

Practice Description:

We are organising a series of workshops for university teachers in material engineering courses, focusing on the identification and implementation of key employability competencies in students. The workshops aim to familiarise teachers with the concept of employability and equip them with the tools to effectively identify and shape these competencies in the teaching process.

Objective:

The aim of the internship is to raise the awareness and competence of teaching staff in identifying and developing employability skills to better prepare materials engineering students for the challenges of today's labour market.

Methodology:

1. Introduction: Presentation of the concept of employability and its relevance in the context of materials engineering.
2. Identification:
   - Analysis of key employability competences for materials engineers
   - Tools and methods for diagnosing students' skill levels
3. Implementation:
   - Strategies for developing employability skills in the classroom
   - Integration of soft skills education with technical content teaching
   - Designing tasks and activities to foster employability
4. Evaluation:
   - Methods for assessing student progress in employability skills
   - Tools for collecting feedback from students and employers
5. Planning:
   - Development of individual plans to implement employability skills in classes

- Discussion and exchange of experiences among participants

Results:

- Increased teacher awareness of the importance of employability skills
- Acquisition of practical tools to identify and assess the level of competence in students
- Development of teaching strategies that integrate technical knowledge with soft skills
- Improving graduates' preparation for the labour market

Conclusions:

The workshop proved to be an effective tool in improving teachers' competences in identifying and implementing employability skills. A systemic approach to the topic and the involvement of all teaching staff is crucial.

Recommendations:

1. Regular training for teachers on employability skills
2. Integration of employability skills diagnosis into the study programme
3. Development of a coherent competence development strategy at faculty/university level
4. Close cooperation with employers to validate learning outcomes

Implementation and Follow-up:

We plan to continue the workshop programme and gradually implement the developed solutions into everyday teaching practice. We intend to extend the diagnosis of employability skills to all students of materials engineering and to create a support system for teachers implementing these competences in their classes.

This internship will contribute to improving the quality of education at our university and better aligning the profile of graduates with the needs of the labour market. As a result, our students will not only have a solid engineering knowledge, but also a set of soft skills, increasing their chances of a successful career in the dynamically changing environment of the materials industry.

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11.7. Good practice: "Improvement workshop on the formulation of learning outcomes".

Practice Description: Organisation of improvement workshops for academic staff focusing on the correct and effective formulation of learning outcomes. The workshop aims to improve the competence of teaching staff in defining clear, measurable and achievable outcomes that are the foundation of well-designed courses and study programmes.

Aim: The aim of the practice is to improve the quality of education by developing a coherent and transparent system of learning outcomes, closely linked to teaching content, teaching methods and ways of verifying student achievement.

Methodology:

1. Introduction: Presentation of the importance of well-formulated learning outcomes in the context of educational quality.
2. Principles for formulating effects:
   - Bloom' s taxonomy and its application in defining effects
   - SMART (Specific, Measurable, Achievable, Relevant, Time-bound) principle
   - Differentiation of outcomes into knowledge, skills and social competences
3. Practical workshops:
   - Exercises in the formulation of learning outcomes for selected subjects
   - Analysis and improvement of existing effects in terms of their quality and measurability
4. Evaluation:
   - Methods for assessing achievement of the learning outcomes
   - Construction of evaluation tools (tests, projects, presentations, etc.)
5. Summary:
   - Presentation and discussion of the developed learning outcomes
   - Discussion of challenges and good practice in formulating outcomes

Results:

- Increased competence of teachers in the formulation of learning outcomes
- Improving the quality and clarity of outcomes defined for subjects and programmes

- Better alignment of teaching and evaluation methods with intended outcomes
- Increasing coherence between learning outcomes, learning content and teaching methods

Conclusions:

The workshop proved to be an effective tool in improving teachers' competences in formulating learning outcomes. The practical approach and the opportunity for participants to exchange experiences is crucial.

Recommendations:

1. Regular training for teachers on how to formulate learning outcomes
2. Review and update of outcomes for all subjects and study programmes
3. Establishment of an educational quality assurance team to monitor the correctness of the effects of the workshop
4. Involving students in the process of defining and evaluating learning outcomes

Implementation and Follow-up:

We plan to continue the workshop programme and gradually implement the developed solutions into teaching practice. We intend to review the learning outcomes for all subjects and programmes in terms of their quality and consistency. We will also set up a learning quality team to ensure that the outcomes are correct and up-to-date.

This practice will contribute to the quality of education at our university by providing clear and well-structured learning outcomes. This will provide students with clarity about expected achievements and give teachers a solid basis for planning lessons and assessing progress. In a broader perspective, well-formulated outcomes will also facilitate the accreditation process and ensure better comparability of diplomas in the labour market.

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11.8. Good Practice: " AI-Buzz: A Workshop for Academic Teachers on Teaching the Use of AI in Brainstorming

Practice Description: Organisation of specialised workshops for academics to prepare them to effectively teach students how to use artificial intelligence (AI) in brainstorming processes, particularly in the context of materials engineering.

Aim: To equip academic staff with the knowledge, skills and tools necessary to teach students the effective use of AI in creative processes, with a particular focus on brainstorming in materials engineering projects.

Methodology:

1. Theoretical sessions:
   - Discussing the role of AI in creative processes
   - Presentation of methods for integrating AI with traditional brainstorming techniques
   - Presentation of AI tools to support brainstorming
2. Practical workshops:
   - Demonstration of selected AI tools to support brainstorming
   - Exercises to teach students how to use AI in brainstorming
3. Development of lesson plans:
   - Creation of own schedules for students by participants
   - Classroom management simulations and feedback from other participants
4. Evaluation: Collection of participants' opinions and evaluation of the prepared material

Results:

- Preparing teachers to teach the use of AI in brainstorming activities
- Development of innovative lesson plans for students
- Increasing competence in teaching modern creative techniques
- Preparation for answering students' questions and concerns about AI

Conclusions:

The workshop effectively prepares teachers to introduce students to the world of AI-enhanced brainstorming. This approach opens up new possibilities in teaching creative problem solving in materials engineering.

Recommendations:

1. Regular workshop updates with the latest tools and trends in AI
2. Creating a forum for sharing experiences of brainstorming AI activities
3. Encourage feedback from students and continuous improvement of methods
4. Organisation of demonstration classes for students by workshop participants
5. Creation of a repository of teaching materials and best practices in teaching the use of AI in brainstorming.

This internship will contribute to the modernisation of teaching methods at the university, preparing students to effectively use AI in creative processes. As a result, graduates will be better prepared to work in an environment where AI is becoming an increasingly common tool to support innovation in materials engineering.

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