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BIOART
Engineering education
for human welfare

Innovative Multidisciplinary Curriculum in Artificial Implants for Bio-Engineering BSc/MSc Degrees

Evaluation of the BIOART project (Duration: October 15 2017 – October 14 2020)

Report Period: October 2017 - October 2019

EU funding instrument: European Neighbourhood Instrument (Erasmus+: KA2 CBHE)

External Expert: MBA, Elena Eyngorn

Content

Abbreviations

BIU	Bar Ilan University
CUT	Cracow University of Technology/Politechnika Krakowska
DSEA	Donbas State Engineering Academy
ECEA	Education, Audio-visual and Cultural Executive Agency
EE	External expert, Dr.Nazokat Kasymova
HEIs	Higher Education Institutes
HIT	Holon Institute of Technology
IUCC	IUCC (MACHBA) – Interuniversity Computation Center
IL	Israel
KU (Leuven)	Katholieke Universiteit Leuven (Catholic University of Leuven)
M&E	Monitoring and Evaluation
NEO	National Erasmus office
PC	Project Coordinator
PMT	Project Management Team
PSTU	Pryazovskyi State Technical University
SCE	Sami Shamoon College of Engineering
SISJP	Sytenko Institute of Spine and Joint Pathology/Academy of Medical Sciences
UA	Ukraine
UCU-DUK	University for Continuing Education – Danube University Krems /Universitaet Fuer Weiterbildung Krems
UPM	Universidad Politecnica de Madrid
VNTU	Vinnytsia National Technical University
ZNTU	Zaporizhzhya National Technical University

1 Introduction

The following is the intermediate evaluation report of the BIOART project. In the evaluation process, the following central questions have been taken into account, specified by the project consortium:

1. What is the current status/maturity of the project, and what issues should be paid particular attention to in order to meet the goals of the project?

2. How does the internal communication and project coordination work in the consortium?

3. How does the project perform in terms of dissemination and communication with relevant stakeholders, and how can these operations be developed?

4. Any suggestions for future collaboration with other similar or neglected stakeholder groups should be presented

5. Any other ideas for developing the project and its working performance should be present

With the objective to adequately answer the above questions, the evaluator conducted a scrutinized review of the documents that the project management has kindly made accessible. The evaluator participated during the training of BIOART and the consortium meeting in Krems, June 2019, and gathered a magnitude of important information regarding the progress of the project, as well as the plans for finalising the tasks of the work packages. The evaluator has also examined additional information available on the project's website. In addition, three members of the Consortium have been interviewed, in order to fill some gaps of information. All interviews have followed a semi-structured format with a prepared interview guide, open to subsequent spontaneous follow-up questions, depending on the answers given. I wish to thank the interviewees for generously taking their time and sharing their views.

Following this introduction, I present a status update of the deliverables of each work package, in relation to the status of them.

1.1. Background

Innovative Multidisciplinary Curriculum in Artificial Implants for Bio-Engineering BSc/MSc Degrees - BIOART

The project is funded with support from the European Commission and addresses the implementation of an innovative Bologna-process type curriculum, which is both a national and regional priority for Israel; the curriculum is related to engineering and engineering trades (artificial implants for bio-eng.), which is a priority both for Ukraine and Israel; it also draws upon many disciplines (health, life sciences, mathematics and statistics, mechanical and electronics eng., robotics, etc.), thus being multidisciplinary, which is a priority for Ukraine.

The **specific objectives** of the project:

- Develop teaching methods for collaborative bionic laboratories;
- Implement an educational program that satisfies market needs, thus increasing employment rates;
- Develop technical and personal competencies required by market and society (e.g., problem-solving, entrepreneurship, collaboration, presentation skills, etc.);
- Establish a framework that allows mobility of engineering students and faculty to study and teach in EU HEIs;
- Increase students' and faculty's expertise while creating long-lasting institutional effects and build a new method of self-learning based on a project-oriented methodology.

The **Main Objective** of the project:

- Develop an innovative BSc/MSc curriculum in Smart Artificial Implants that fits current needs of the labor market to increase internationalization and cross-regional level cooperation among partner countries as well as develop knowledge triangle innovation in Artificial Implants design, manufacturing and maintenance

According to the specific project objectives the following principal **Outputs and Outcomes** should end the project:

- An improvement of the educational process by setting up novel curricula with new/updated courses combined fundamental and applied multidisciplinary knowledge based on integration of current research from robotics, digital signal processing (DSP), computer vision, and new materials manufacturing and with modern laboratory equipment and software that will help to address social cohesion and unemployment issues;
- A network of multi-disciplinary specialists in different fields related to bioengineering that will help to address sustainable development in the target countries through improved education;
- Increased internationalization and cross-regional level cooperation;
- Knowledge triangle innovation in Artificial Implants design, manufacturing and maintenance in the partner universities.

BIOART Work plan

Ref.#	Activities	Number of weeks (total duration)
1.1.1.	Curricula Analysis related to BIOART studies in target HEIs in UA/IL	9
1.1.2.	Regional summary analysis of existing curricula in engineering courses with the emphasis on artificial implants and bio-signals	3
1.2.1.	Survey on competences in Artificial Implants required at a labor market	9

1.2.2.	Meetings with industrial partners	2
1.2.3.	Summary of SWOT Analysis for the region	6
1.3.1.	Setting a strategic plan for cross-regional knowledge triangle network	10
2.1.1.	Curriculum/Modules development in EU countries	12
2.2.1.	Modules/curriculum development in Partner countries	6
2.3.1.	Training in Bio-Medical System Design (TMMA)	14
2.4.1.	Local teacher training	3
3.1.1.	Setting QAG and preparing QAP	4
3.2.1.	Monitoring key indicators	8
3.3.1.	Performing satisfaction surveys among the target groups	4
3.4.1.	Internal quality assessment	8
4.1.1.	Develop University-Enterprise collaborative group	4
4.1.2.	Develop a collaboration plan	8
4.1.3.	Implementation of dissemination strategy	16
4.2.1.	Develop Project web-site	6
4.2.2.	Develop collaborative virtual environment	6
4.2.3.	Maintenance of the project web-resources	16
4.3.1.	1st project meeting	12
5.1.1.	Define Hierarchical Project Management Structure	6
5.2.1.	Project budget monitoring	8
5.2.2.	Project activities monitoring	8
5.2.3.	Daily management tasks	8
5.3.1.	Kick-off meeting	5
5.3.2.	Short management meetings	2

Consortium Partners: EU countries: 4 universities**;** Partner countries: 8 universities, 1 Inter-university center.

1	Universidad Politecnica de Madrid - http://www.upm.es	Spain
2	Cracow University of Technology/Politechnika Krakowska - https://www.pk.edu.pl	Poland
3	University for Continuing Education – Danube University Krems/Universitaet Fuer Weiterbildung Krems - http://www.donau-uni.ac.at	Austria
4	Katholieke Universiteit Leuven/Catholic University of Leuven - https://www.kuleuven.be	Belgium
5	Zaporizhzhya National Technical University - www.zntu.edu.ua	Ukraine

6	Donbas State Engineering Academy - http://dgma.donetsk.ua	Ukraine
7	Vinnytsia National Technical University - https://vntu.edu.ua	Ukraine
8	Pryazovskyi State Technical University - https://pstu.edu	Ukraine
9	Sytenko Institute of Spine and Joint Pathology of National Ukrainian/Academy of Medical Sciences (Ukraine) - http://www.techprofiles.org/index.php/ukrainian-institutes/929-institute-of-spine-and-joint-pathology	Ukraine
10	Sami Shamoon College of Engineering - https://en.sce.ac.il	Israel
11	Bar Ilan University - https://www.biu.ac.il	Israel
12	Holon Institute of Technology - https://www.hit.ac.il	Israel
13	IUCC (MACHBA) – Interuniversity Computation Center - https://www.iucc.ac.il	Israel

The project has started in October 2017 for an overall project duration of three years. Project Quality control is implementing on the basis of the target universities' quality assurance systems. The list of activities on quality evaluation included: comparison with the timetable of the project activities in Work plan; Evaluation of outcomes and their quality in form of Questionnaire / Survey reports received from target students /academics/ stakeholders.

External expert is responsible for midterm and final project evaluation.

A result-based external evaluation was used as a method to assess the mid-term project's results/outputs and indicators' achievement.

The external evaluation focuses on the binding indicators of the project vice-versa the project monitoring is based on routine data collection (as a responsibility of the project team it presents in the partners' reports).

As the External evaluation is included the description of the status of achievement for each binding indicator it is feasible to come to assumptions and corresponding recommendations by the analysis of the relationship between activities and indicators' status in terms of the project's goals and objectives.

1.2 Reporting Structure and Format

The Evaluation report provided by the External Expert will support the project management team to make the right decision in terms of project implementation vis-a-vis reaching the objectives of the project.

The report provided three parts:

- The introductory notes, including the project background, evaluation method, as well as a description of the reporting process and data sources;

- The analytical overview includes highlights of the overall findings (general) as well as summaries of status, risks, achievements and recommendations (specific, per indicator) on the project.

1.3. Reporting Process and Data Sources

The Evaluation reporting process follows the standard procedures for management processes, decision-making, and planning processes, reporting lines and procedures, as well as the distribution of responsibilities for the collection of routine information on project events and activities.

Corresponding to the standard procedures, the EE relies on the following data sources (means of verification) as the information basis of the report:

- **Project Reports and other data.** The partners' activity reports provided core information on the project, including presentations of partner universities at regular project's meetings/conferences. In addition, some internal documents including communication between the partners, curricula, methodical materials, dissemination information were reviewed. The compilation and analysis of this information provide the information basis of this report.
- **EE's Access to the project's documents package and web-site.** The EE received access to the project's website and technical documents.

1.4. Project Indicators

The project has it an own system of binding indicators based on its objectives:

Specific Project Objective 1: Develop teaching methods for collaborative bionic laboratories.
Indicator:

- New teaching methods developed.

Specific Project Objective 2*:* Implement an educational program that satisfies the market needs to increase employment rates.
Indicator:

- New educational programmes (curricula) that responded to labor market needs are implemented.

Specific Project Objective 3*:* Develop the competences and skills (technical and personal) necessary for the Labor Market in Artificial Implants Bio-Engineering and society (e.g., problem-solving, entrepreneurship, collaboration, presentation skills, etc.).
Indicator:

- Technical and personal competencies of students developed in the frame of curricula.

Specific Project objective 4: Establish a framework that allows the mobility of engineering students and faculty to study and teach in EU HEIs.
Indicator:

- The Framework for mobility to study and teach in the EU established.

Specific Project objective 5: Increase students' and faculty's expertise while creating long-lasting institutional effects and build a new method of self-learning based on a project-oriented methodology.
Indicators:

- Students and faculty expertise is increased;
- A new method of self-learning based on project-based methodology is introduced.

The main project objective: Develop an innovative BSc/MSc curriculum in Smart Artificial Implants that fits the current needs of the labor market to increase internationalization and cross-regional level cooperation among partner countries as well as develop knowledge triangle innovation in Artificial Implants design, manufacturing, and maintenance.
Indicators:

- New innovative BSc/MSc curricula in Artificial Implants for Bio-Engineering developed by the partner HEIs;
- Networking and Joint Cooperation in Artificial Implants Bio-Engineering at the cross-regional level established;
- Knowledge triangle innovation is in place.

2. Analyses: Indicator Status, Risks, Achievements and Recommendations

2.1. Indicator Status

Indicator	Summary Status
1.Specific Project Objective 1: Develop teaching methods for collaborative bionic laboratories ***Indicator:*** New teaching methods developed	1.1. An innovative academic environment for bioengineering curricula is in the process of developing; 1.2. Existing laboratories and teaching facilities in the partner universities are under the modernization with some delay in purchase of equipment due to substantial rearrangement of the original proposed equipment list; the final procurement plan was submitted and approved in Dec'18; 1.3. New equipped workstations and laboratories are installed before pilot teaching during the academic year 2018-2019 and for effective education in the multidisciplinary science of bioengineering at the partner institutions (*DUK: 1 Lab*; *HIT: 2 GPU labs, 10 work stations with GPU server, Augmented Reality Development Kit; BIU: 2 computer clusters for big data analysis & storage/workstations; SCE: 1 Lab with Bitalino Acquisition Cards; Bioplux Signal Explorer Kit; INKREDIBLE+ 3D-bioprinter – Cellink; One*

	bioreactor – Solaris; Software – CES EDUPack 2019; Sensors and Actuators; DSEA: 2 Labs in Biomechanics and Bioelectronics with power supply unit, digital microscope; electromechanical universal testing machine; digital oscilloscope; ZNTU: 3 Labs incl. diagnostic set; PSTU: 4 Labs - Additive manufacturing implants by 3D-printing; Virtual reality; Bio tribological studies; Diagnostics of medical equipment; VNTU: testing machine and multimedia equipment); 1.4. The partner universities provided additional co-financing to equip labs (*DSEA*).
2. Specific Project Objective 2**:* Implement an educational program that satisfies market needs to increase employment rates ***Indicator: New educational programmes (curricula) responded to labor market needs are implemented	2.1. Educational needs in Bioengineering were determined in each partner university through the problem and job analysis, and review the current curricula to define multi-disciplinary challenges of the area and the new skills needs in bioengineering; 2.2. The partner universities reviewed/analyzed curricula/course modules within bachelor and master study programmes with focus to labor market needs (*DUK: 8 BSc and 9 MSc programmes; HIT: 3 BSc; BIU: 2 BSc; SCE: 8 BSc; DSEA: 5 curricula and 14 syllabus in BSc; 5 curricula and 8 syllabus in MSc; ZNTU: 4 BSc and 3 MSc; VNTU: 8 BSc and 4 MSc);* 2.3. Innovative new educational curricula of Artificial Implants for Bio-Engineering including guidelines/methodical materials are adopted by target universities and in the process of integration at the institutional level; 2.4. Students defended bachelor/master thesis related to the project issues (*SCE: 2 BSc; DSEA: 8 BSc and 2 MSc; ZNTU: 13 BSc and MSc and 3 Ph.D. students; VNTU: 5 BSc and 4 MSc);* 2.5. Project results/information presented and discussed within the methodological and research community of the partner universities (*DSEA: 2 presentations at the Research Council).*
3. Specific Project objective 3: Develop the competences and skills (technical and personal) necessary for the Labor Market in Artificial Implants Bio-Engineering and society (e.g., problem-solving,	3.1. Additional courses in artificial implants for biomedical engineering, suited for both B. Sc. and M. Sc. Degrees are developed;

entrepreneurship, collaboration, presentation skills, etc.) ***Indicator:*** Technical and personal competencies of students developed in the frame of curricula	3.2. The number of electronic resources/materials developed and disseminated through the project website; 3.3. The Working Group was established to compose of EU and non-EU to create the materials for the different topics; 3.4. Research-based sessions and roundtables organized in the HEIs (*DUK)*; 3.5. Teaching materials published at the partner institutions to assist the newly developed curricula/course modules (*SCE: 3*; *VTNU: 1 (Biochemistry);* 3.6. Students studied on newly developed modules/courses (*DSEA: Methods of Digital Information Processing in 2018-19, 30 students; VTNU: Biochemistry course, 10 students*).
4. Specific Project objective 4: Establish a framework that allows mobility of engineering students and faculty to study and teach in EU HEIs ***Indicator:*** The Framework for mobility to study and teach in the EU established	4.1. The Website of the project was created and is available since June 2018 but with some delays in the subcontracting for the website maintenance; the partner universities have web-sites to reflect project's activities/outputs and share information/news on the project (at universities home pages in Ukraine, Hebrew; German and English) (*HIT: Research, Innovation, and Internalisation (R&D) web page –link to the projects, under the "Awards & Achievements);* 4.2. The main stakeholders (MoEs, related HEIs and non-academic sector) actively participated in project's conferences and seminars to share/disseminate project's experience and ideas (*DSEA: 2nd and 3rd All-Ukrainian Science and Technology conferences "Modern information technologies, automation and electric drive", at DSEA –19-21 Apr'18 and 18-20 Apr'19 with the section on the BIOART project and abstracts publication; conference "Modern education: Accessibility, Quality, Recognition", DSEA, Nov. 14-15, 2018; IT Connect 2018 and 2019; seminar "UkrInTech", 25 June'19; AERO-UA 2019, HORIZON – 2020; "SmartPicnic" IT Developers Open Conference and Children's Robotics Festival "RoboSmart", 15 June'19 (Slovjansk); ZNTU: International scientific-practical conference Modern problems and achievements in the field of radio engineering,*

	telecommunications and information technologies, ZNTU, 3-4 Oct'18; Informatics & Data-Driven Medicine: 1st International Workshop (IDDM 2018); CADSM 2019; IX International Scientific and Practical Conference on; MEMSTECH 2018; Dortmund International research conference; Second International Workshop on Computer Modelling and Intelligent Systems (CMIS-2019); 3rd practical conference: "Current issues of treatment of pathology of joints and end prosthetics"); ZNTU Annual scientific-practical conferences «Science Week-2018» and «Science Week-2019; VNTU: Scientific and Technical Conference, 22-23 March'19; ISJP; International conference Advanced Treatment of Hip and Knee Pathology, 24-26 Apr'19; Section BioArt at All-Ukrainian scientific-practical Internet conference of students, graduate students and young scientists "Youth in Science: Research, Problems, Prospects, 11-30 May'19; Section BioArt at First International Scientific and Technical Conference "Prospects for the development of mechanical engineering and transport-2019, 13-15 May'19; Scientific-practical round table "Health Economics - Wealth and Strength of the Territorial Community", Polyana, Ukraine, 16 May'19; PSTU: conference of the Department of Biomedical Engineering, 6 Sept'18; meeting of the National Methodical Committee/Ministry of Education and Science, 20-22 June'19; International Conference "Advanced Treatment of Hip and Knee Pathology", SISJP, 25-26 Apr'19; Section BioArt at International Scientific conferences "University Science – 2018", "University Science – 2019", 16-17 May'19; Section BioArt at International Scientific-practical conference "Sustainable development of Ukraine: Challenges and ways of solution", 7-8 Nov'19; SISJP: 16th International symposium of minimal invasive spine surgery in cooperation with International Society for Minimal Intervention in Spine Surgery (ISMISS/SICOT) North American Spine Society (NASS), and International conference «Advanced treatment of hip and knee pathology", where

	special sessions were devoted to project activities; 4.3. Staff mobilities carried out in the field of (bio-)technology and digitalization (*DUK: 4 staff mobilities*; *HIT: 1 new mobility grant with UPM);* *4.4.* Faculty staff and students of the partner universities trained in the EU HEIs – CUT Biomaterials to Nanostructures, June'18 (IL – 6 participants and UA – 14 participants) and UPM Signal Processing for Biomedical Engineering, Jan-Feb'19 (Il -8 and UA -13); *4.5.* The academic mapping for the partner-countries was made (Curricula and labor market analysis: IL, UA; Austria, Germany, Switzerland, Spain).
5. Specific Project objective 5: Increase students and faculty expertise while creating long-lasting institutional effects and build a new method of self-learning based on a project-oriented methodology ***Indicators:*** Students and faculty expertise is increased; A new method of self-learning based on project-based methodology is introduced	5.1. The current methodology implemented in the partner universities reviewed and gaps/problems defined to implement and accredit new practice-oriented course curricula including ECTS; 5.2. The Surveys of students on the level of awareness of BIOART project were conducted in the partner HEIs (*HIT: Nov'19; BIU: Oct'19; DSEA: Feb-March'18, ZNTU: May'18, 80 students; VNTU; PSTU*); 5.3. Follow-up seminars for teachers and students - based on the results of training in EU universities (*DSEA: 3 and 3 with total 48 teachers and 84 students; ZNTU: 5 masterclasses, 42 participants; VNTU: 3 with 42 participants);* 5.4. Training courses/masterclasses for other teachers organized by the partner institution (*VNTU: 3 with 48 participants; ZNTU: 5 with 18 participants*; 5.5. E-materials developed for all new and modified disciplines to use in Moodle for students and teachers to share methodological support and tests; 5.6. E-learning materials published at the partner institutions to assist the newly developed curricula/course modules (*VTNU: Biochemistry*).

6. The main project objective: Develop an innovative BSc/MSc curriculum in Smart Artificial Implants that fits current needs of the labor market to increase internationalization and cross-regional level cooperation among partner countries as well as develop knowledge triangle innovation in Artificial Implants design, manufacturing and maintenance ***Indicators:*** New innovative BSc/MSc curricula in Artificial Implants for Bio-Engineering developed by the partner HEIs; Networking and Joint Cooperation in Artificial Implants Bio-Engineering at the cross-regional level established; Knowledge triangle innovation is in place	6.1. The project is implementing based on its Work Plan and according to the LogFrame Matrix (LFM); 6.2. Project's website is developed and regularly renewed - https://bioart.iucc.ac.il/ - including project's summary, academic content; presentations, teaching materials, and dissemination info; 6.3. Kick-off and coordination meetings were conducted in the WP timeframe; 6.4. Curricula package prepared by EU partner universities was transferred to adapt in target HEIs (*DUK: Extracorporeal blood purification and detoxification; Implantable sensors and systems; Optical sensors for biomedical applications; Regenerative Medicine; Blood-Material-Interaction has withdrawn due to IPR issues)*; 6.5. A list of curricula/modules is agreed upon by target HEIs and complied with national standards;
6.7 Curriculum Package to develop/update is agreed and approved by each target university (HIT: Deep learning and its applications in bioengineering, ECTS: 6, BSc.; Introduction to Neural Implants, ECTS:6, BSc., Neural Implants Applications, ECTS: 6, BSc. - Bioengineering route, 3rd or 4th year of studies; BIU: Computational Biology for Engineers, ECTS:3, BSc; Biological Data Science, ECTS:6, BSc; DSEA: Biomechanics; Biomedical Systems, Materials, and Technologies; Designing and Manufacturing of Medical Products; Digital Processing of Biomedical Signals; IT in Medicine (Methods and Systems of Artificial Intellect in Medicine); Mathematical Processing of Medical Biological Data; Technologies for Receiving and Transmitting Medical Data for BSs; and Processing of Biomedical Images And Reconstruction of Objects; Modern Information Technology in the Industry; Regenerative Biomedical Technologies and 3D Printing of Implants; Hardware, Software and Medical Engineering Support of Bioengineering, Medical Devices, and Systems for MSc; VNTU: Biochemistry; Measuring information converters and sensors for medical and engineering systems;	6.6. Curriculum Package to develop/update is agreed and approved by each target university (*HIT: new courses: Biomedical Digital Signal Processing; Signal Recognition Techniques by Machine Learning; Introduction to Neural Implants (6 ECTS); Neural Implants: Application (6 ECTS); BIU: Computational Biology for Engineers, ECTS:3, BSc; Biological Data Science, ECTS:6, BSc; SCE: updated courses: Digital Signal Processing (5.25 ECTS): Additional lectures on Biomedical DSP; Digital Image Processing (5.25 ECTS): Additional lectures on biomedical image processing methods for segmentation; new courses: Mathematical methods using Python (4.5 ECTS); Introduction to Machine Learning (4.5 ETCS); Biopolymers engineering (3.75 ECTS); Biomaterials production and characterization (4.5 ECTS); Structure and properties of materials for medical applications (3.75 ECTS); 3D printing for biomaterials (3.75 ECTS); Biomaterials: mechanics and architecture (4,5 ECTS); DSEA: Anatomy and physiology of human; Units and elements of medical equipment; Biomedical systems and technologies; Mathematical processing of medical biological data; Biomechanics; Mathematical modeling and*

Nanotechnologies in biomedical science; Mathematic modeling in biomedical science; Digital circuit engineering; Biomedical mechanics; Biophysics; Higher mathematics for BSc and Processing of biomedical images and reconstruction of objects; Modern information technology in the industry; Regenerative biomedical technologies and 3D printing of implants; Hardware and software and medical engineering support of bioengineering and medical devices and systems for MSc;	*mathematical statistics in biomedical systems; Information technology in biotechnology systems for BSC total 24 ECTS; Automated design of optimal designs for medical purposes; Design of modern information systems; Computer technologies in medical-biological researches for MSc in total 10 ECTS; VNTU: new/updated courses: Biochemistry; Measuring information converters and sensors for medical and engineering systems; Nanotechnologies in biomedical science; Mathematic modeling in biomedical science; Digital circuit engineering; Higher mathematics; Processing of biomedical images and reconstruction of objects; Modern information technology in the industry; Regenerative biomedical technologies and 3D printing of implants; Hardware and software and medical engineering support of bioengineering and medical devices and systems in total 33,5 ECTS; ZNTU: updated courses: CAD/CAM/CAE of Medical Systems (5 ECTS): module "Additive methods in bioengineering (3D printing)" (2.5 ECTS); Embedded biomedical systems and wireless sensor networks (4.5+1.5 ECTS): modules "Wireless sensor networks" (2 ECTS) and "Optical sensors for bio-medical applications" (2 ECTS); Biomedical materials and constructions (5 ECTS): modules Biomaterials I & II (1.5 ECTS each); Medical information infrastructure (5.5 ECTS): modules "Sensor principles: bioimpedance and biophysical sensors" (1.5 ECTS) and "Biomechanics (Sensoring and non-destructive tests on implants in situ)" (3 ECTS); Methodology of scientific research (3 ECTS): module "Monte Carlo methods for estimation and optimization" (2 ECTS); Machine Learning and Artificial Intelligence (5 ECTS): module "Signal recognition techniques by machine learning" (4 ECTS); Biomedical signals and signal processing (5.5 ECTS): modules "Biomedical digital signal processing" (3 ECTS) and "Statistical signal processing" (2 ECTS); Modern nanotechnology (3 ECTS): module "Nanostructures and nanocapsules" (1.5 ECTS); new courses: Apparatus and Systems for Medical Diagnosis (4+1.5 ECTS);*

	Telemedicine (3 ECTS); PSTU: updated courses: Biomedical digital signal processing module (2 ECTS, BSc); Regenerative medicine and biotechnology in orthopedics (3 ECTS, MSc); Machine Learning and Artificial Intelligence module (1.5 ECTS, BSc); new courses: 3D printing for biomedical applications (4 ECTS, MSc); Biomaterials (4 ECTS, BSc); Bio-ceramics (3 ECTS, MSc); Nanostructures and nano-capsules (3 ECTS, MSc); Computer simulation of multi-body models (4 ECTS, MSc); Sensors for bio-medical applications (4 ECTS, MSc); 6.7. Bologna Process' approaches considered as a priority for national programmes; 6.8. Project products and services contribute to the strengthening of the network of teachers and students in Artificial Implants Bio-Engineering at national and regional levels; 6.9. Cooperation with non-consortium organizations interested in the project (*DUK: ACCENT/Tech Incubator in Lower Austria participated in the project workshops and supported project dissemination activities with partner companies and professionals; DSEA: agreement with the implant manufacturing company "Motor Sich CJSC", 2017; Kramatorsk Hospital and Diagnostic center for students internship in 2018 and 2019; computer science lessons in Kramatorsk Schools N3, N35; DonPhTI NAS of Ukraine, "UkrIntech" Kharkiv; Micas Simulations Limited, Oxford, UK – QFORM; ZNTU: JSC Motor-Sich (implants and instruments production); PCF MOTOR; VNTU: Vinnytsia state experimental prosthetic and orthopedic enterprise; Stock Company Regional Dental Clinic; PSTU: Mariupol City Hospital #4; City inter-district oncology clinic of Mariupol, Medtekhnika Mariupol LTD);* 6.10. Dissemination Plans developed in each partner university that also includes active promotion of the project outside of the consortium (*DUK: presentations at Karl Landsteiner University, University of Applied Sciences Krems and TU Vienna);* *6.11.* Quality Assurance Plans developed in each partner university and integrated into

	their quality management system to assure quality and performance *(the final QA Plan was approved in the meeting in Jan'18);* *6*.12. Quality Management related activities are well-coordinated and monitored; the project QA group consists of the members of the Project Steering Committee; 6.13. Research papers based on the project outputs published in national journals/foreign journals (*SCE: 1; DSEA: Sahaida P.I., Zory A.A. "Components of computer systems for intelligent data processing based on categorical and ontological models", Kramatorsk, DSEA, 2019 - 159 p. in Ukranian; 2; ZNTU: 3; VNTU: 3 + 4 in 516 p.; PSTU: Azarkhov, A., Fedosova, I. Levytska, T., Efremenko, V., Cheiliakh, O. Automated information system for the rehabilitation of post-stroke patients in the residual period. 2nd International Workshop on Computer Modeling and Intelligent Systems, CMIS 2019; CEUR Workshop Proceedings Volume 2353, 2019, Pages 378-390; A. Azarkhov, S. Sakalo, V. Efremenko, E. Sorochan, I. Fedosova, S. Danylkov Radiothermometric measurements of biological objects deep temperature. Proceedings of 2019 IEEE 39th International Conference on Electronics and Nanotechnology (ELNANO), P. 435-429; Azarkhov A.V., Efremenko V.G. Radiothermometric method of measuring the deep temperature of biological objects. Proceedings of International Scientific Conference "University Science – 2019", PSTU, Mariupol, 2019, P.8-9; Азархов А.Ю., Ефременко В.Г., Ефременко Б.В. Перспективы развития специальности БМИ в свете реализации образовательного проекта «BioArt». Proceedings of International Scientific Conference "University Science – 2019", PSTU, Mariupol, 2019, P.9-11);* 6.14. Contributions published in proceedings of national conferences/international conferences (*SCE: 1; DSEA: the "Academy" newspaper*; 13; *ZNTU: 13; VNTU: newspaper "Impulse"; 27);*

	6.15. Cooperation with other HEIs interested in the project (*VNTU: Vinnytsia National Medical University named after MI Pirogov);* 6.16. Collaboration in the frame of other Erasmus + programmes *(two KA1 agreements have been signed with SCE and ZNTU; an extended KA1 proposal including SCE, HIT and BIU was submitted in Feb'19).*

2.2. Risks/Assumptions Assessment

Indicator	Risks/Assumptions Summary
1.Specific Project Objective 1: Develop teaching methods for collaborative bionic laboratories ***Indicator:*** New teaching methods developed	• The outflow of trained staff in Labs; • Lack of funds in the partner universities to motivate staff and maintenance the equipment; • Poor collaboration with the Labs outside of the partner universities and networking.
2. Specific Project Objective 2*:* Implement an educational program that satisfies market needs to increase employment rates ***Indicator:*** New educational programmes (curricula) responded to labor market needs are implemented	• Lack of good assessments on labor market needs at national and regional levels; • Non-involvement of employers/enterprises/business sector/civil society into the curricula development; study process (masterclasses) and practice (mentorship); • Non-transparency of the partner universities (entry rates, employment rates, graduates' competitiveness);.
3. Specific Project objective 3: Develop the competences and skills (technical and personal) necessary for the Labor Market in Artificial Implants Bio-Engineering and society (e.g., problem-solving, entrepreneurship, collaboration, presentation skills, etc.)	• Lack of cooperation with employers (national enterprises, small and medium business and innovation centers) to organize job fairs, students/graduates conferences, and seminars;

Indicator: Technical and personal competencies of students developed in the frame of curricula	• Lack of capacity in Quality Assessment in the partner universities; • Poor quality of follow-up training to disseminate knowledge/skills in the partner universities.
4. Specific Project objective 4: Establish a framework that allows mobility of engineering students and faculty to study and teach in EU HEIs ***Indicator:*** The Framework for mobility to study and teach in the EU established	• The weak interest of students, faculty staff and administration in mobility; • Lack of funds in the project and additional funds of the partner universities to provide mobility; • Poor foreign language skills of the target groups.
5. Specific Project objective 5: Increase students and faculty expertise while creating long-lasting institutional effects and build a new method of self-learning based on a project-oriented methodology ***Indicators:*** Students and faculty expertise is increased; A new method of self-learning based on project-based methodology is introduced	• Lack of own financial resources in the partner universities for student self-development programmes/projects; • Lack of faculty capacity and methodology packages in the partner universities on new Teaching and Learning (T&L) tools.
6. The main project objective: Develop an innovative BSc/MSc curriculum in Smart Artificial Implants that fits current needs of the labor market to increase internationalization and cross-regional level cooperation among partner countries as well as develop knowledge triangle innovation in Artificial Implants design, manufacturing and maintenance ***Indicators:*** New innovative BSc/MSc curricula in Artificial Implants for Bio-Engineering developed by the partner HEIs; Networking and Joint Cooperation in Artificial Implants Bio-Engineering at the cross-regional level established; Knowledge triangle innovation is in place	• Political and economic stability in the region; • Changes in current bylaws/MoE instructions/decrees in UA (positive and negative); • Difficulties in the accreditation process for curricula/modules; • Absence of independent associations/organizations that can conduct the accreditation process in UA; • Language skills (UA); • Lack of motivation of university staff to improve the quality of services (salaries, overloads, additional hours, etc.).

2.3. Achievements and recommendations

Indicator	Achievements	Recommendations
1.Specific Project Objective 1: Develop teaching methods for collaborative bionic laboratories ***Indicator:*** New teaching methods developed	• Equipment for the Labs are purchased and delivered for the partners, but in some case, it was a serious delay with delivery due to the need of preparing a revised procurement plan w.r.t. the application (for UA partners the procurement plan had to be registered at the Ministry of Economy, and for IL partners there was an issue with VAT of purchased equipment; (*VTNU: delay in 1.5 years*); • Joint training with representatives of the partner universities are avoided to share information and experience; • The BIONIC laboratories are in the process of upgrading.	• Continuing training of Labs' staff to motivate it; • Search for additional projects/funds/counterparts to ensure the Labs' sustainability.
2. Specific Project Objective 2*:* Implement an educational program that satisfies market needs to increase employment rates ***Indicator:*** New educational programmes (curricula) responded to labor market needs are implemented	• National professional standards/competencies are compiled to the modernized Curricula Package; • The novel curriculum in artificial implants for Bio-Engineers is developed and started to implement in the partner universities; • There is an opportunity to develop a Ph.D. program or joint degree programs in partner universities.	• Focus on # of students enrolled in the new/restructured programmes (% growth); • Assess the satisfaction of the employees by the curricula at the project end.

3. Specific Project objective 3: Develop the competences and skills (technical and personal) necessary for the Labor Market in Artificial Implants Bio-Engineering and society (e.g., problem-solving, entrepreneurship, collaboration, presentation skills, etc.) ***Indicator:*** Technical and personal competencies of students developed in the frame of curricula	• Training for the faculty staff on a new methodology is conducted in 2019; • The new curricula demonstrate the integration of a multidisciplinary programme with EU-based methodology, use of on-line resources, and interactive research-based teaching; • New competences in Artificial Implants for Bio-Engineering are formulated in the partner universities.	• Activate online communication and discussions between the partner universities (online courses; platforms for students and faculty staff); • Collaborate with the business sector to attract recourses for further sustainability of project results/outputs; • Increase the involvement of students in the project management/technical support.
4. Specific Project objective 4: Establish a framework that allows mobility of engineering students and faculty to study and teach in EU HEIs ***Indicator:*** The Framework for mobility to study and teach in the EU established	• The EU universities are also benefited from the project (*DUK: Sensors and Sensor Systems course is an extension for future technology teaching in the medical faculty; other courses reviewed and improved in quality during preparation for the project; academic teachers trained and increased their skills and knowledge; DUK: an intermediary institution for innovation transfer and support of SME and founders, has been established and the project was presented there)*; • Training courses for academic and non-academic staff were	• Focus on student innovative projects and mobility; • Develop strategy and Action Plans for student & staff mobility cooperation projects or joint startups; • The project partner teachers (including other staff categories) passed courses in EU countries; • Training courses/master workshops organized by the EU institutions in 2019 (*DUK: 4 courses, 21 participants, total of 37,5 hours; 4 days workshop with guided site and lab visits -total number 7; DSEA: 5 faculty staff participated; VNTU: 4; PSTU: 2 in Sept'18 and March'19 with 23 participants).*

	conducted and the participants satisfied; • 82 academic staff, 22 students and 12 admin are trained in total on the EU universities; • The achieved level of networking and cooperation are considered as one of the main values of the project partners.	
5. Specific Project objective 5: Increase students and faculty expertise while creating long-lasting institutional effects and build a new method of self-learning based on a project-oriented methodology ***Indicators:*** Students and faculty expertise is increased; A new method of self-learning based on project-based methodology is introduced	• The project supports the internationalization of all the institutions involved, as well as the modernization of the education systems in partner countries; • 30% of courses should be taught in foreign language, but hardly to be reached due to legal regulations for teaching language and capacity of the students (parts of teaching/reading material, presentations or assignments in English) – (*ZNTU*: *at least 1 course of the partner universities should have material in English to have a proof of foreign language*); • The student contest is ensured in the project.	• Need to intensify project information/products dissemination among students; • Quality Assessment Plan in the partner-universities can be integrated into the QA system at the institutional level; • Need in additional resources assurance for innovative projects.
6. The main project objective: Develop an innovative BSc/MSc curriculum in Smart Artificial Implants that fits current needs of the labor market to increase internationalization	• The project created good opportunities for cooperation between UA and IL universities; • Proposed curricula are supposed variation and flexibility (each university or system can define and manage own set of	• Need to activate focus on ECTS component to integrate it more into the curricula package; • Active involvement of Methodical councils/units of the partner HEIs into the project's implementation; • New/updated curricula package should have complied with

and cross-regional level cooperation among partner countries as well as develop knowledge triangle innovation in Artificial Implants design, manufacturing and maintenance ***Indicators:*** New innovative BSc/MSc curricula in Artificial Implants for Bio-Engineering developed by the partner HEIs; Networking and Joint Cooperation in Artificial Implants Bio-Engineering at the cross-regional level established; Knowledge triangle innovation is in place	curriculum/module with main focus on its structure and content); • The process of curricula/modules updating/integration into Curricula Package of target universities is ongoing; • The final version of modules and courses provided by EU partners; • New modern courses more suited to the industry needs are developed and learning outcomes are also part of the new/updated courses; • Syllabus for the newly developed courses following an agreed standard template and following the principles set out in the Bologna process, all the newly developed courses will include a syllabus with a detailed description of ECTS and activities performed by the students; • ECTS is in the process of introduction in UA and IL and Bologna requirements are declared at the national level; • A modular structure of the educational process with a competences-based approach is in the adaptation process; • The partner universities are in the process of preparation and collection of documents for accreditation;	national standards/or vise versa national standards should be modernized (UA); • Focus on development and publishing of methodical aids/textbooks in the partner universities; • Training/seminars on Bologna process requirements (including ECTS); • Need to continue to promote Bologna process elements and disseminate info among faculty/administrative staff and students of the partner universities; • The necessity for strong coordination among stakeholders to guarantee project sustainability; •

	• The EU universities provided the best practices on the Quality Assurance Management system based on continuous development, expansion and integration of the quality instruments to a single, comprehensive quality management system and a deeply-rooted, all-encompassing quality culture. It includes quality standards, quality assurance procedures and instruments defined in various guidelines, announcements and the quality handbook (*DUK*); • Sharing of documents is not optimal since no collaborative platform exists and the platform of UPM has severed delays due to the restricted upload policy (only the coordinator can upload); • The EU universities had the opportunities to update their course materials and teaching contents in the related areas; • New partnerships and collaborations, particularly with IL and UA partners, were established for joint research proposals, staff mobilities as well as student exchange on the Ph.D. level being discussed as future opportunities;	

	• The project demonstrates the enhancing collaboration between the different specialties and expanding inter- and multi-disciplinary activity throughout the partner universities; it supports an interdisciplinary approach in academic teaching and research; • The project supports to develop an innovative environment and modern intellectual multi-culture capacity in the partner universities that fit with their institutional and national strategies; • The project encourages to develop advance mixed e-learning platforms which incorporate international faculty staff and students.	

3. Management and internal communication

Successfully managing Capacity Building projects of this type requires a special skills-set. In this project the central coordination and leadership has been complemented by distributive management and leadership across the project organization community to a greater extent. It is reasonable to assert that managing projects like this is particularly demanding because success depends so heavily on motivation and effective group dynamics within the organizations themselves, and across the project team. In BIOART the project management processes are considered as having been excellent. Reporting has been timely, comprehensive and highly articulate. Responses to problems have been immediately considered in a consensus-driven way, with support given and actions taken. Financial management has been based on sound systems. It is not within my remit to analyses financial reporting other than to note that it has been facilitated by a high level of coordination expertise, supported through the use of accessible documentation templates, and timely. The budget and expenditure is within overall budget headings.

The management and coordination (both centrally and amongst partner organizations has successfully maintained excellent coherence between the work plan and activities, and the activities and timeframe. As with all project of this complexity with respect to the breadth of the partnership there has been some minor time lag on certain developmental aspects but these have been overcome, and do not impede the design, creation and testing of the deliverables as of towards the end of 2019. The outcomes of the project have been very tightly monitored with corrective measures adopted when necessary by the coordinator. In most respects the project has been paced ahead of sub-schedules which has been advantageous in providing additional time for team review and further consolidation of deliverables.

The consortium members, I have interviewed for this evaluation report are of the understanding that the project has been well managed and that the internal communication has been working well. Judging by the collaboration between the WPs and the continuous progress of the project, one interviewee draws the conclusion that the communication within the consortium has probably worked very well, although a general notion is that a number of online coordination meetings (via skype, zoom, etc) should be increased. The communication between the consortium and the Project Management Board is regarded as well functioning. After the meetings, the management have provided summaries of project output, which have been useful in order to follow the progress of the project.

Recurrent in the interviews with the partners is a perception of previous worry of delays in deliverables (equipment purchase) due to the national regulations. However, as the project has progressed, the effectiveness of the project management has improved and most deliverables are now published or timewise under control. Another issue of worry has been the change of the consortium partner Thomas More, which was replaced by KU Leuven. It is of course always frustrating to any project with such changes, but when they happen, it is of key importance that the new partner puts efforts into understanding the project and acts in a supportive manner.

- **Individual attitudes towards own participation in the project**
  How satisfied are you with your own participation in this project?

- Somewhat satisfied 13 %

- Completely satisfied 89 %

- **Individual attitudes to self-participation**
  How would you describe the participation of your organization in the project over the whole period up until now?

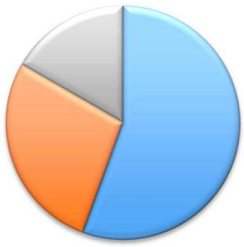
- Some participation 11 %
- Extremely high participation 89 %
- Some participation 5%

- **Individual attitudes towards participation of other partner organizations**
  How satisfied are you with the participation of the other partner organisations in this project?

- Somewhat satisfied 11 %
- Completely satisfied 89 %

- **Individual attitudes on decision-making processes**

  How comfortable are you with the way decisions are made?



- Somewhat comfortable 17 %
- Extremely comfortable 55 %
- Very comfortable 28%

- **Individual attitudes on communication frequency through the whole project time-frame**

Please rate your frequency of communication (by telephone, e-mail, etc.) with the rest of the participants in the project?

- Very frequently 45 %
- Extremely high frequency 43 %
- Somewhat frequently 10 %
-- Low frequency 2 %

3.1 Dissemination and communication with relevant stakeholders

From the first year of the BIOART project, dissemination have been structured in specific dissemination plans within the framework of WP4. The plans have been updated once a year, following internal evaluations. The dissemination plans have identified (proposed by PSTU) relevant stakeholders and different channels for communicating the results of the project. The dissemination strategy states a "lively and well-functioning communication and cooperation with related EU-projects". This statement is in accordance with the general perception observed in the interviews, that the communication and interaction with external participants of the project overall has been working very well and that the dissemination has reached relevant stakeholders.

Considering the size of the project and the way it is structured, the observation I have, is that the involved stakeholders have been sufficient and relevant, and that the dissemination overall has been appropriate given what the project wanted to achieve.

The parts of the dissemination and external communication identified as troublesome are mainly referred to as general and common problems within EU-projects. Throughout EU-projects, there is a lack of partners and stakeholders from Europe, and one interviewee states that it would have been desirable to involve partners that gave the project more geographical spread. It is also suggested to include EU enterprises and NGOs in future collaborations concerning public engagement. Industrial partners could contribute with intermediation towards a more unusual public to the academic world. It is a major issue to reach a less educated public, which the NGOs could help with.

In this final phase of the BIOART project, it is naturally essential to pay particular attention to finalizing all the remaining deliverables.

It is suggested that the dissemination could have been more active from the beginning, and aimed at involving and informing more stakeholders than has been the case. Not least could more industrial partners and also academic organisations have been involved. The project topic

as such calls for particular attention and efforts in this respect. To put substantial effort into dissemination and outreach during the project's final phase seems to be of key important in order to meet expectations from the EC and the public. Moreover, there should be plans for how to sustain the project's outcomes after the project has ended. The project website is the key outcome and disseminating it seems highly important. Any measure that can be taken, by BIOART, in order to secure sustained relevance of the project, will be of critical importance and should be given high priority.

4. Conclusions and lessons learned

- The project is balanced, WP well developed and implemented by appropriate manner; the partner universities reported good coordination, regular feedback, and support from the PMT;
- TMMA requested to withdraw from the project due to internal reorganization in 2018 and a new partner (KU Leuven) was invited;
- All intermediate products and services produced by the project (results/outputs) are reflected in quantity and quality points (including results date/milestones achieved) in quality evaluation reports provided by each of the partner universities as well as the general report of the PC;
- Results/outputs of the project were compared with the WP and in terms of achievement to project's indicators;
- Project progress is monitored through data collection and analysis as well as performing regular evaluation surveys and reporting & documentation in the frame of the project QA mechanism;
- Project communication is ongoing through skype working group meetings and email;
- Project website and collaborative space needs to develop further and regularly update;
- At the beginning of the project, there was a lack of common understanding of basic HE terminology used (e.g. different understanding and definitions of module-course-curriculum-syllabus, etc.); course structure at different countries; national reports and coverage of the subjects in curriculum development, but the problems were solved;

- As pilot teaching has started in 2019-2020 academic year there is a need to close monitoring of the process;
- Strengthen the student innovation contest and pilot teaching in the project with ensuring the number of students enrolled in the programme (15-25 on average) (*based on the concept for the student contest/UPM teleconference and DUK lecture for innovation transfer for the student contest, WIKI setup, Unico*);
- Focus on students' bachelor/master thesis related to the project issue (BSc and MSc);
- Needs to involve active students/graduates in project management;

- Assess students' opinion on passed newly developed courses/modules (probably additional surveys);
- Intensify mobility among the partner universities for students and faculty staff;
- Search for more collaboration at the country's level with related universities and centers;
- Analyze the National Qualification Frameworks and diploma recognition in Bioengineering to support further cooperation and attractiveness of the project;
- Intensify networking of the partner universities and non-academic communities (enterprises, NGOs) to strengthen links with labor markets and society;
- Cooperate with start-up incubators for academics, tech freelancers, professional developers, and entrepreneurs to support technology companies, which in turn creates more job opportunities and drives innovation and technology development at national and regional levels;
- Develop agreements between the partner institutions and other co-operating education institutions/entrepreneur companies/stakeholder organizations to sustain the project's services;
- The partners can start to work on further joint projects;
- Intensify work on methodical materials based on training in EU universities;
- Focus on training follow-ups and information sessions to increase dissemination impact of the project;
- Prepare and conduct online methodical conferences/seminars/webinars in the partner universities;
- Prepare to join scientific papers within the project based on additional cost-sharing funding as the project is not covering this part of the activity;
- Joint publications will be useful for all partners and can promote Bologna process values at the related HEIs and countries;
- Prepare mentors in the bio-medical/chemical area as an additional value of the project (*SCE and SISJP*);
- Transfer knowledge to industry about changes in an academic area (share new training materials, educational resources and provide information sessions);
- Pay more attention to co-financing in the frame of the project and its further sustainability;
- Continue to promote the project and share its products at international seminars, student fairs, and conferences (*such as the Student Hackathon planned in CUT at the end of the project*);
- Intensify effective dissemination of the project information (publish its findings via both traditional media (e.g. press relation) and digital media (e.g. social media);
- Regularly update the project website as a major interface and community-building platform (training and teaching materials, webinars, results of the Feasibility Study, Repository entry point, methodological materials, reference materials), make links to other available web-based dissemination channels (universities' websites, mailing lists, community resources, etc.);

- Place at the website the set of traditional promotional materials (publications in media and professional journals/ conference presentations/posters/interviews, stories); results of the briefing meetings with policy-making stakeholders to enable a multiplier effect);
- Organize a weekly mailing-list to keep the technical people involved in the project in the long-term; consider admin cost for full-time project management in each partner institution probably based on the cost-sharing mechanism.

Appendix 1.

The list of documents from the BIOART project

- Project Proposal
- Project's LFM, Work Plan and description of activities
- Quality Assessment strategy and plan; Dissemination plan
- Intermediate Quality Evaluation reports of the partner universities
- Documents of kick-off and main coordination meetings (agendas, presentations, minutes and lists of participants)
- Dissemination products: leaflets, relevant websites' pages;
- Curricula and Teaching materials
- Surveys report at the country level
- Project website