Educational Programme Management Methodology for Research Projects

Alkistis Kontou[1*], Kai Heussen[2], Leonard Ramos Perez[3], Panagiotis A. Karafotis[4], Mazheruddin Syed[5], Alexandros Paspatis[6], and Evangelos Rikos[7]

[1]School of Electrical and Computer Engineering, National Technical University of Athens, Athens, Greece
[2]Department of Wind and Energy Systems, Technical University of Denmark, Roskilde, Denmark
[3]European Distributed Energy Resources Laboratories (DERlab) e.V., Kassel, Germany
[4]Hellenic Electricity Distribution Network Operator (HEDNO), Athens, Greece
[5]Energy Advisory, WSP UK, Glasgow, United Kingdom
[6]Department of Engineering, Manchester Metropolitan University, Manchester, United Kingdom
[7]Centre for Renewable Energy Sources and Saving, Athens, Greece
[*]alkistiskont@mail.ntua.gr

***Abstract*—Smart grids and intelligent energy systems play a pivotal role in fostering the sustainable advancement of our civilization. Over the past few decades, power systems, like many other sectors, have undergone a rapid digital transformation. This rapid development necessitates a proactive response from universities, research institutes, industry stakeholders in relation to educational programmes. Educators must rapidly adapt their curricula and teaching methodologies to effectively train the next generation of engineering professionals. While curriculum crafting for new educational programs is inherently challenging, another layer of complexity arises when research collaborations in large consortia are tasked with delivering high-quality education within a given project scope and time frame. This paper outlines a methodology for establishing an educational strategy for such research projects. This approach takes into account the available resources and expertise of the project participants, while embracing modern, learner-centric educational methodologies. It also ensures alignment with broader objectives or frameworks. Furthermore, the strategy incorporates a dynamic evaluation process that runs concurrently with the educational activities. Finally, the ERIGrid 2.0 H2020 project upon which the proposed methodology was developed, is presented as a case study.**

***Index Terms*—educational programme management, educational strategy, training activities.**

I. Introduction

Like in many other industries, the energy landscape has been evolving faster than ever in the past decade with the emergence of new technologies and sciences shaping the future. This accelerated transition poses two challenges in relation to the workforce: (i) the rapid growth of the sector has outpaced the availability of skilled professionals, and (ii) with the emergence of new technologies and sciences, there is a lack of workforce with specialist skills that can ensure the growth and sustainability at pace [1], [2]. Apart from the technical aspects that need to be tackled in the frame of the energy transition, a very important aspect that requires attention is the adaptation and modernization of the power systems education. This gap in availability of skilled professionals highlights the importance of ongoing skills development and training.

To effectively address the gaps in skills shortage, training and skills development at all stages and ages is essential. To educate and prepare the new generation of researchers, engineers and professionals, the curricula across different education levels - primary and secondary school, undergraduate, masters and Ph.D. syllabi - should be updated and enhanced. Furthermore, opportunities for individuals looking to make a change in career through acquiring knowledge should be provided. One instance of this approach is the National Transition Training Fund in Scotland [3]. This initiative financed the creation of a set of short, targeted training programs, known as micro-credentials. These programs were designed for individuals who faced redundancy due to the uncertainties posed by COVID-19. The aim was to help them not only preserve their current employment but also acquire the necessary skills to transition into sectors anticipated to have significant future growth potential [3]. Energy infrastructure related education at the community level is also crucial, as it empowers individuals and local organizations to actively participate in the energy transition, make informed choices, and contribute to a more sustainable and reliable energy future. An example of such an approach funded by H2020 is the MOST (Meaningful Open Schooling Connects Schools To Communities) project that brings together school and community members to focus on scientific approaches to regional sustainable issues ranging from waste management to energy saving [4].

To enhance educational experience, foster the acquisition of fresh skills and abilities, and cultivate a versatile interdisciplinary foundation, it is imperative to utilise the variety of mediums of delivery available. The usual practices of delivery of educational activities such as lectures, seminars, workshops should be complemented by development of e-learning tools and materials, e.g., webinars, online simulation tools, e-books and videos. Learning through hands-on laboratory practices can help assimilate knowledge by bridging the gap between theory and its applications [5]. An example of an action funded by the EU is the EMMA (European Multiple MOOC Aggregator) platform that aims to demonstrate excellence in pioneering teaching techniques and educational approaches by conducting extensive pilot programs of free delivery of MOOCs (Massive Open Online Courses), in multiple languages and broad range of subjects [6].

There is focused effort in development of training and skills through dedicated educational projects. Multiple frameworks have funded several projects focused on engineering education through the years, e.g., projects funded by the Erasmus Europe or Horizon Europe actions in the EU [7], UKRI in the UK [8], and NSF in the USA [9], with elaborate educational methodologies and extensive outcomes, e.g. MOOCs [10], lecture notes [11], student and staff exchanges [12] etc. The challenge identified in this paper focuses on research projects instead. Research projects outnumber projects that have a dedicated focus on education around the world, with their technical aspects covering a wide range of activities, usually extending the existing knowledge/practice. Due to the pace of the energy transition, converting such research outputs to training programmes is of utmost interest, and their effective integration into education is essential. A coordinated effort in bringing research and education together can foster a culture of continuous and innovative learning, paving path towards preparing a highly skilled and agile workforce capable of driving sustainability and growth in the energy sector.

Developing educational curricula, courses and training events is a common practice within the educational community, where frameworks, programme management and pedagogical approaches are well established and utilised. This paper discusses the challenges of development of educational material within research projects, particularly looking at the adoption of typical educational programme management. Having highlighted the challenges, the paper proposes a revised programme management methodology more applicable for adoption by research projects. The application of the methodology to ERIGrid 2.0 (European Research Infrastructure supporting Smart Grid and Smart Energy Systems Research, Technology Development, Validation and Roll Out – Second Edition) H2020 project [13], for development and dissemination of research knowledge is reported as case study.

II. Educational Programme Management for Smart Energy Systems

A well aligned educational programme facilitates the coordination of learning and skill development activities in a specific area. This section presents key elements of educational programme management and identifies the opportunities of adopting this methodology for the implementation of an educational strategy in research projects.

A. Elements of Educational Programme Management

The process of development of educational programme management can be divided into three logical stages as: (i) preparation and planning, (ii) implementation and evaluation and (iii) sustainability and compliance, each of them briefly described below.

1) Preparation and Planning: Identification of the target audience is the first step in development of an educational programme management followed by the identification of their needs. It should be acknowledged that students enter formal education with varying levels of prior knowledge, skills, beliefs and concepts that immensely shape their approach to observation of the environment and influences how they structure and comprehend information [14]. A number of methods are typically employed to assess the knowledge and skills the educational programme should address, for example, undertaking research, conducting interviews and surveys. The second step in the development of the educational programme is to ascertain the intended learning objectives and outcomes. More often Bloom's taxonomy is adopted for the purpose of defining the intended learning objectives and outcomes [15]. Once defined, the strategies and methods for delivering the instructions are set. The next step is to define the assessment criteria and approach. Finally, a detailed plan is developed for delivery. It is imperative that situational constraints are taken into consideration when the learning objectives, the instruction strategies and assessments are designed. Additionally, the success of the programme hinges upon timely identification of adequate resources (funding an personnel) for the delivery of the programme.

2) Implementation and Evaluation: The second stage of the programme management involves the execution of the programme as per the designed plan. This involves the delivery of all planned educational activities such as lectures and tutorials. At this stage of the programme, it is essential to continuously monitor its progress. It is important to have quality control measures in place to ensure the high standards. Gathering feedback serves as an opportunity to assess if the programme meets its objectives and to adapt and improve as necessary.

3) Compliance, Promotion and Sustainability: It is important to ensure the developed programme abides by relevant laws and regulations, including educational standards and ethical guidelines. Plan to attain any accreditation are set and reviewed regularly. Throughout the process it is beneficial to engage with necessary stakeholders including learners, teachers, parents and community members to incorporate their input and ensure their support. Development of strategies to promote the programme to attract audience is crucial for the success of the programme. Evaluating the programmes impact and effectiveness is necessary to ensure long-term sustainability of the educational programme. Effective mechanisms for resolving any disputes promptly should be in place. It should be a practice to regularly review and revise the program to adapt to changing needs and circumstances.

B. Challenges in Application of Educational Programme Management to Research Projects

In this section, the challenges in application of educational programme management to research projects are identified. As the methdology of educational programme management outlined above was designed for educational institutions, there are differences in the requirements of managing educational programmes within a research project. However, we can identify a good number of similarities, which suggest adoption of educational programme management methods summarised above. The following sections first highlight the similarities that warrant adoption, then we identify differences which motivate adaptations to the methodology for application in research projects.

1) Similarities: In both, educational programme management and the application to research projects, identifying the target audience is a fundamental step in the development process. The need to accommodate diverse levels of prior knowledge, skills, beliefs, and concepts among the audience is also common in both contexts. Tailoring educational activities to address these varying needs and competences is a shared objective. In both contexts, a course or training activity can be organised around clearly identifiable target competences. The method of defining "intended learning outcomes" as a tangible and testable formulation of the competences, is practice-proven in higher education, and equally applicable to research-based training activities.

Further, the use of Bloom's taxonomy is a widely accepted technique to organise and structure intended learning outcomes, equally relevant for research related competences. In terms of programme implementation, there is in both educational programmes and in research projects a practical separation between the roles of organising the programme and of implementing the educational activities. This separation necessitates a strategic coordination to ensure alignment and effective delivery of planned activities. Quality control measures are essential in both contexts to maintain high standards and continuously monitor progress. Research projects are evaluated (quality control) and need to follow certain standards of quality set by associated educational institutions (compliance).

Both research projects and educational programmes are meant to deliver an impact beyond the programme end. Strategies to promote the programme or project to attract and engage the audience or stakeholders, e.g., for adoption of developed training modules, are therefore vital for success. Evaluating the impact and effectiveness of the programme or project is necessary for long-term sustainability, enabling adjustments and revisions to meet changing needs and circumstances.

2) Differences: While educational programme management often involves a hierarchical organizational structure, this is not easily applicable to large research projects, which comprise numerous organizations and stakeholders. In research projects, the targeted competences are not entirely identifiable at the outset or by the programme management, as research results need to be translated into training activities during the project cycle based on the evolving project outcomes.

Assessment, an important aspect in educational programme management, is typically not directly applicable in research projects, especially when European Credit Transfer and Accumulation System (ECTS) credits are not involved. Moreover, there's a challenge in assessing tacit skills in research projects, which are difficult to measure directly. In educational programmes there is usually continuity in the target audience, which enables competence build-up, but also requires curricula to be coordinated. In contrast, research project training audiences are not expected to attend any sequence of activities. Training activities associated with a research project often conclude with the project's lifecycle, making them relatively short-lived compared to educational programmes. Conversely, educational programmes aim for enduring impact and may involve more continuous and long-term engagement with the audience beyond specific projects.

These differences highlight the need for a nuanced approach in applying educational programme management principles to research projects.

III. Proposed Methodology

As outlined above, there are elements of programme management that pertain to educational efforts in research projects, and elements that differ fundamentally. This section outlines how key elements of programme management may be adopted and how the approach can be modified to suit for educational activity coordination in research projects.

The applicability of classical educational programme management for large research projects hinges on an hierarchical organisation with the possibility of setting authoritative directions on building competence and targeted learning outcomes from the outset, and implementation policies. In contrast, research projects are distributed and targeted learning outcomes are subject to development. However, it is possible to adopt programme management elements into an alternative system of bottom-up definition and discovery of required competence and learning outcomes. We propose an agile combination of parallel bottom-up and top-down processes for the creation of training activities and their alignment through an educational strategy.

The proposed approach (as shown in Fig. 1), involves an initial conception and a cyclic update of an educational strategy, which is informed through the structured reporting of bottom-up created training activities. The analogy of the

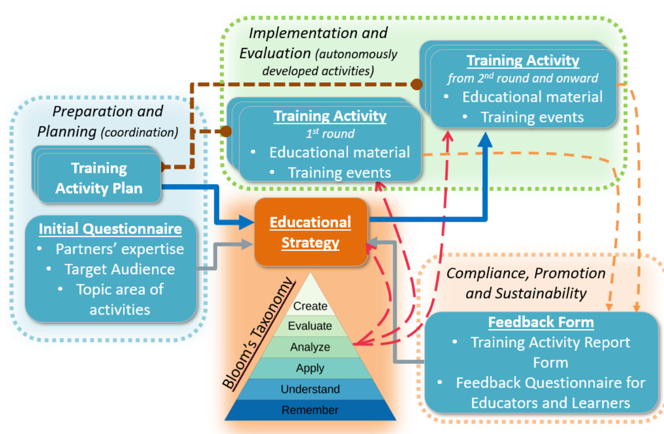

Fig. 1. Schematic diagram of the process for the educational programme management.

proposed approach to the elements of the conventional educational programme management is drawn within Fig. 1. The four steps involved are described in detail below.

Step 1: As a first step, the technical areas, scope and ambitions of the project are identified, in order to set a direction for the educational programme. The educational program leader in consultation with all the actors involved (e.g., the partners which will carry out the activities) defines the technical topic areas which will be covered within the educational activities and their prioritisation. Generally, those topics are determined by the scope of the research projects and should be aligned with the expertise of the partners and their expectations with respect to the knowledge areas. In order to define the topics, an internal survey with the actors involved can be performed and the respective results analysed to come up with a final list. Likewise, the target groups to which the activities are addressed as well as the validation tools are determined in consensus.

Step 2: In the second stage takes place the development of the training activities and their description. Additionally, forms can be designed and filled for each activity in order to describe the aspects such as learning objectives, activity description, attendance, and other aspects, referred to as the training activity plan. This allows the traceability of the educational programme and a quick access to the key details of each activity held.

Step 3: The first iteration and cyclic update are then informed through bottom-up reporting, the technical topic areas, means of delivery as well as the training objectives and intended learning outcomes are collected. The reporting is organised via a template, training activity report, that informs the developers of training activities about the methodology and the required information. It is also recommended to design questionnaires in which the participants of the activity evaluate their experience and knowledge acquired. The feedback will support to the improvement of further educational activities by tackling weaknesses identified by the participants and will be addressed to both educators and learners.

Step 4: In the last stage is performed an overall analysis of the educational activities to draw conclusions on achievements and lesson learnt. For this purpose, statistical analysis can be carried out to quantify the number of activities performed at each topic area, percentage target groups reached, etc. Therefore, conclusions can be drawn together with the actors involved in the research project. With the collected information, the ongoing direction of the training programme can be monitored and mapped against the ambitions set out for the project. Due to the cyclic update, the project participants are informed on the progress with respect to the set project ambition. This feedback enables the possible re-focussing and creation of additional training activities (in area, activity type, and intended learning outcomes) to meet the project ambition.

IV. Case study: ERIGrid 2.0 Educational Strategy

This section presents the experience from application of the above described methodology to develop and implement an educational strategy for a research project. ERIGrid 2.0 aims to expand the research services and tools provided by leading European research infrastructures for the validation of smart energy systems considering a holistic and cyber-physical systems-based approach. The goal was to effectively develop, deliver and coordinate educational activities related to the project's outcomes (and the overall framework), in order to minimise the time required to interpret the research developments into training material that address the evolving needs of the energy sector and enhance the skills of the workforce. The case study is realized as follows.

Step 1: This step involved setting a direction for the educational programme by defining the technical topic areas, validation method and target groups to be covered in the train-

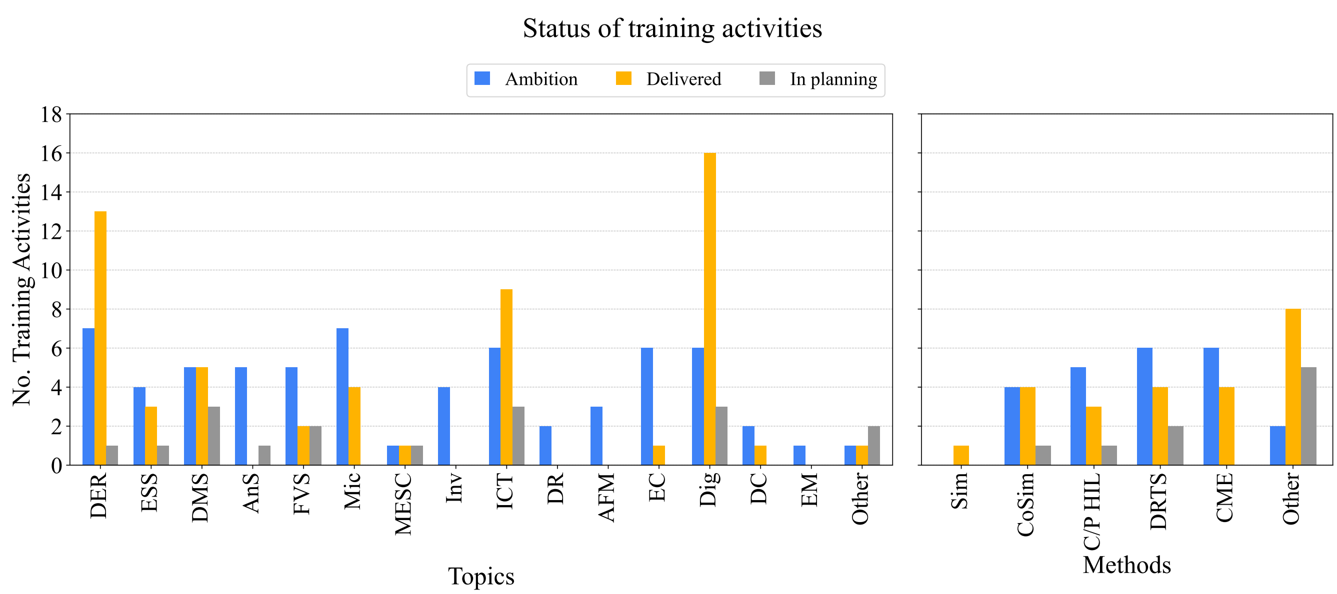

Fig. 2. Analysis of topics and methods covered by ERIGrid 2.0 project's training activities.

TABLE I
LIST OF TECHNICAL TOPIC AREAS. DEFINITIONS, WHERE NOT OTHERWISE REFERENCED, ARE FOUND IN [16]

Technical Topic Area	**Abbrev.**	**Reference**
Distributed Energy Resources	DER	[17]
Energy Storage Systems	ESS	[18]
Distribution Management Systems and Distribution Network Operation	DMS	
Ancillary Services by DG, Storage and Active Grid Assets	AnS	[19]
Frequency and Voltage stability	FVS	
Microgrids	Mic	[20]
Multi-energy/carrier systems/sector coupling	MESC	
Inverter Dominated Power Systems	Inv	
ICT in Smart Grids	ICT	[21]
Demand Response	DR	[22]
Aggregation and Flexibility Management	AFM	[23]
Energy Communities	EC	[24]
Digitalization of Energy Systems	Dig	
DC Power Systems	DC	
Energy Markets	EM	[25]
Other	Other	
Validation Methods	**Abbrev.**	**Reference**
Simulations (Monolithic)	Sim	
Co-simulation	CoSim	[26]
Control and Power Hardware-in-the-loop	C/P HIL	[27]
Distributed Real Time Simulation	DRTS	[28]
Coupling of multiple entities	CME	
Other	Other	

ing activities. ERIGrid 2.0 project defined a set of application areas in an effort of setting a mutual understanding of areas which are of interest to the project as reported in [29], which were further developed into concept profiles, as summarised in [30]. Drawing from these, the relevant technical topic areas to be covered by the educational activities were identified, which are listed in Table I. Next, partners expressed their preferences in terms of technical topic areas, validation methods and target audiences, based on their expertise as well as their preferable means of delivery.

Step 2: Once the technical topic areas, validation methods, target groups and means of delivery of relevance for each partner were specified, the partners proceeded to develop specific training activities related to those. Training activity plans were created and distributed, describing the training objectives, intended learning outcomes based on Blooms Taxonomy, activity descriptions, and other relevant aspects.

Step 3: The ERIGrid 2.0 project followed a cyclic reporting process where technical areas, delivery methods, training objectives, and intended learning outcomes were continuously monitored and reported, using activity report forms. Additionally, feedback from participants was collected, aiding in the improvement of future educational activities.

Step 4: The project conducted an initial analysis of the delivered and under preparation educational activities to draw a first set of conclusions on achievements and lessons learned, in the mid of the project. Statistical analysis was performed to quantify the activities performed/to be performed in each topic area and assess the reach to the target audience. This data was used to make informed decisions, assess the discrepancy between the initial target and the current status, assess the level

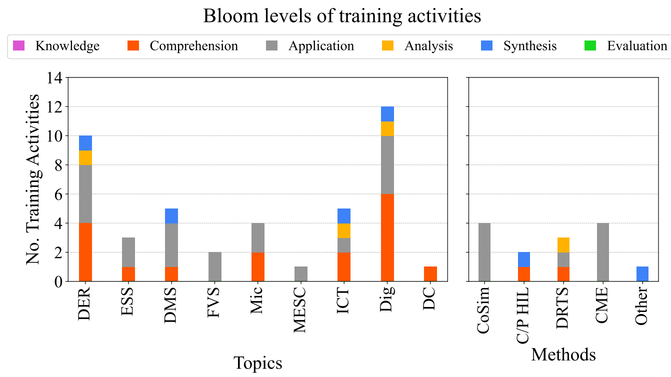

Fig. 3. Categorisation of Bloom levels in the topics and methods covered by ERIGrid 2.0 project's training activities.

of comprehension achieved, so far and use this information to provide directions for future developments and continuously improve the training programme.

In Fig. 2, the ambition of the partners at the beginning of the project, the activities that are already delivered and those that are in planing status are presented. It can be easily observed that DER, ICT, and Dig have been technical topic areas covered by most of training activities, whereas the topics Inv, DR, AFM and EM have not been addressed in any planned or executed activities yet. Fig. 3 provides a reflection on the intended learning outcomes of the project's training activities. More specifically, a view of the categorisation according to Bloom Levels with respect to the technical topics and validation methods and tools covered by the training activities of project is shown. The "Application" level is dominant in both topics and methods. Audience of different skills and background are targeted by the training activities of the project - with power system professionals, young researchers and PhD students being the most prominent - in order to expand and enhance the ERIGrid 2.0 project's impact. The target groups of the training activities of the project are presented in Fig. 4.

The ERIGrid 2.0 project effectively applied an adaptive educational programme management methodology, aligning with the proposed steps. The identification of technical areas and scope, development of training activities, continuous reporting and monitoring, and subsequent analysis for improvement all contributed to a successful educational strategy within the project. This case study showcases how adherence to

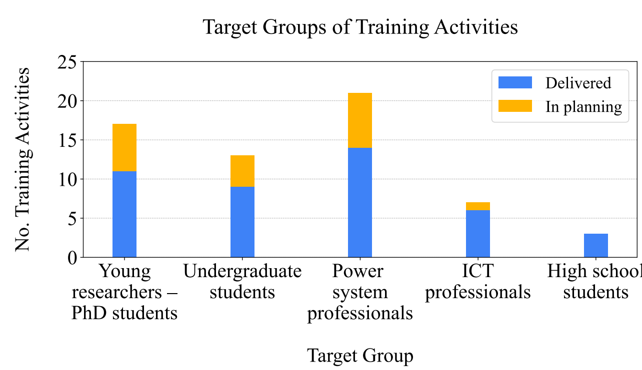

Fig. 4. Target groups of ERIGrid 2.0 project's training activities.

these steps can lead to a relevant impact, and continuously improving educational initiative within a research project.

V. Conclusions

The evolving energy landscape, marked by rapid technological advancements, necessitates a proactive approach in addressing the widening skills gap within the workforce. The challenges posed by this transition demand a rethinking of traditional educational paradigms. This paper highlights the critical role of educational programme management in research projects, emphasizing the need for adaptability and alignment with the dynamic nature of the energy sector. By incorporating a flexible and agile educational strategy that combines bottom-up and top-down approaches, research projects can systematically bridge the gap between evolving research outcomes and targeted learning objectives. This approach ensures that educational activities are well aligned with project goals, enhancing the relevance and impact of the knowledge disseminated.

The proposed methodology, as demonstrated through the ERIGrid 2.0 project case study, showcases the successful application of educational programme management principles within a research project context. The holistic consideration of technical topics, target audiences, and learning outcomes enables tailoring of training activities for their continued alignment with research outcomes, and holds the potential to address the evolving needs of the energy sector. By implementing this adaptable methodology, research projects can effectively translate research outputs into impactful training programs, fostering a culture of continuous learning and innovation.

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