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WP 3 – MSc course design and operations

D3.3 Trial run of MSc course

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## Table of Contents

About TeachHy .....	4
Deliverable Abstract .....	5
1 Programme Preparation .....	6
1.1 Teaching Approach .....	6
1.2 Implementing first trial runs of TeachHy content .....	6
1.3 Administrative process at UBHAM .....	6
1.3.1 Programme start.....	6
1.3.2 UK Home Office and visa issues.....	7
2 Programme Delivery .....	8
2.1 Curriculum .....	8
2.2 Test run Birmingham .....	9
2.3 Other trial implementations.....	10
2.3.1 Trial at Grenoble INP-UGA.....	10
2.3.2 Trial at POLITO: remote laboratory .....	10
2.3.3 Trial at UPB .....	12
3 Summary Conclusions .....	13



## About TeachHy

As the FCHT industry gradually emerges into the markets, the need for trained staff becomes more pressing. TeachHy2020, or short TeachHy, specifically addresses the supply of undergraduate and graduate education (BEng/BSc, MEng/MSc, PhD etc.) in fuel cell and hydrogen technologies (FCHT) across Europe.

TeachHy2020 will take a lead in building a repository of university grade educational material, and design and run an MSc course in FCHT, accessible to students from all parts of Europe. To achieve this, the project has assembled a core group of highly experienced institutions working with a network of associate partners (universities, vocational training bodies, industry, and networks). TeachHy offers these partners access to its educational material and the use of the MSc course modules available on the TeachHy site. Any university being able to offer 20 to 30% of the course content locally, can draw on the other 80 to 70% to be supplied by the project (and its successor entity that will support the platform post-project).

This will allow any institution to participate in this European initiative with a minimised local investment. TeachHy will be developing solutions to accreditation and quality control of courses, and support student and industry staff mobility by giving access to placements. Schemes of Continuous Professional Development (CPD) will be integrated into the project activities. We expect a considerable leverage effect which will specifically enable countries with a notable lack of expertise, not only in Eastern Europe, to quickly be able to form a national body of experts.

TeachHy will offer some educational material for the general public (e.g. MOOC's), build a business model to continue operations post-project, and as such act as a single-stop shop and representative for all matters of European university and vocational training in FCHT. The project partnership covers the prevalent languages and educational systems in Europe. The associated network has over 70 partners, including two IPHE countries, and a strong link to IPHE activities in education.



## Deliverable Abstract

The first trial delivery of the TeachHy MSc programme was conducted at the University of Birmingham in the academic year 2021/22, starting on 27 Sept 2021.

This deliverable summarises the activity.

Deliverable D3.4 will report on the second MSc run, which started on 26 Sept 2022, and would be considered the first full implementation of the programme.

## 1 Programme Preparation

### 1.1 Teaching Approach

TeachHy modules have from the start (2017) been set up as 'blended learning', i.e. as a mix of online and in-person teaching. Covid has taught us that this approach is the most sustainable under all conditions, as it offers the highest level of flexibility and resilience. In practical terms we have used the approach post-Covid as a 'flipped classroom' model, where the students watch all content as recorded lectures online, before then attending a number of tutorials in person (or online, but synchronous, i.e. live). This creates some issues with undergraduate students (not represented in the TeachHy programme) but receives positive feedback from students from 4th year and MSc cohorts due to the increased flexibility in following the material.

### 1.2 Implementing first trial runs of TeachHy content

It was found very early in the project that several universities were not in a position to consider accreditation of MSc content even far before the Covid pandemic, due to not allowing any new courses to begin in 2018 (ULB) or due to the overall length of administrative processes.

Various project partners, amongst them INP Grenoble, TU Delft (later replaced by Rijksuniversiteit Groningen), University of Birmingham (UBHAM), Politecnico di Torino (POLITO), Ecole Polytechnique de Lausanne (EPFL), Kyiv Politechnic Institute (KPI) and Universite Libre de Bruxelles (ULB) have been using the material supplied in TeachHy from 2018 onwards to deliver lectures and modules to Master programme level students in the context of other programmes, for instance Advanced Energy Technologies in Schools of Mechanical Engineering, Chemical Engineering degrees etc.

This implementation of TeachHy content in other contexts has been used to obtain feedback and continuously improve and update the individual module content prior to the full MSc programme run.

It was therefore decided to implement the first version of the TeachHy MSc programme content on the UBHAM Learning Management System (LMS) CANVAS. Once this was complete and tested, it would be copied to the LMS of the Prague University of Chemical Technology (VSCHT/UCTP).

### 1.3 Administrative process at UBHAM

#### 1.3.1 Programme start

The onset of the COVID crisis slowed progress in 2020, although the TeachHy approach at blended learning exactly met the needs of online teaching under conditions of a pandemic. When attempting to start the first programme trial run in the academic year 2020/21, UBHAM administration refused permission on the grounds that no new programmes were to be started under Covid lockdown circumstances under a categorical university policy.

The permission to start advertising and teaching the MSc programme at UBHAM was finally received in May 2021. Student recruitment normally occurs earlier in the year and marketing had some difficulties in understanding what and how to advertise the scheme.

We nevertheless obtained 5 students responding positively to the university offer letters. As is often the case with new programmes, but also due to the late advertising, students with unusual careers and needs were attracted and thus

- 1 student deferred to the next academic year due to personal circumstances,
- 1 student accepted in part-time studies and is splitting the year across two calendar years,
- 1 student took a break from studies (Leave of Absence, LoA) due to circumstances explained below,
- 2 students followed regular lectures through to graduation.

### 1.3.2 UK Home Office and visa issues

As all teaching had to go online during the Covid lockdowns, there was a common understanding between UK universities that students would not attend teaching in person and therefore could attend classes from wherever they were located on the globe. Normally, though, in-person attendance is required and monitored, especially for the international students. Students receive a specific (Tier 4) visa for this. Students following online-only courses and programmes ('distance learning', DL) are not issued student visas. If they need to enter the country (e.g. for exam purposes or the degree ceremony) they can do so on a tourist visa.

UK universities understood that the current (temporary) situation would neither completely coincide with on-campus, nor DL delivery, but rather with what is understood as 'blended learning', i.e. part delivery of education in-person on-campus, part online. The Home Office completely misunderstood and misjudged this and then started contesting any visas to be granted to 'blended learning' registered students. For this reason the Chinese student on the academic year 2021/22 programme was refused a visa to attend classes and the research project in person. Until this situation was principally cleared with the Home Office (with the goal to obtain full visas for 'blended learning' registered students) the student took leave (LoA), i.e. took a break from studies.

As a consequence of this situation, the programme was in 2022/23 set up in two different versions, 'on campus' and 'distance learning', which are essentially identical from the programme content. The only impact is the type of visa the students will receive for their studies.

## 2 Programme Delivery

### 2.1 Curriculum

Flipped Classroom means that students receive the lecture material upfront of the interactions with the lecturers in order to prepare, read, and formulate any questions they might have. In-person lectures and tutorials are then located towards the end of the course and do not serve the purpose of transferring knowledge, but rather as Q&A sessions, exercises, and additional information events. In the context of the arrangements found at UBHAM for the Covid Years 2020 & 2021 this meant that students were given access to the online material one week ahead of the timetabled module ('Release Week'). The following week ('Support Week') opened with an Induction Tutorial on the Monday morning (in hybrid mode, i.e. in-person attendance with the option to participate online), followed by two online-only tutorials on Thursday and Friday morning, and two mainly in-person (hybrid if feasible) tutorials on the Thursday and Friday afternoons. This format has now been adopted for all TeachHy MSc modules at UBHAM.

In order to support student time management, the sub-units of a modules are structured such that one unit approximates one regular teaching day (3 to 4 lectures of 90 minutes). Students can only pass from one unit to the next when they have concluded the previous unit, i.e.

- visited all lecture pages, and
- completed all quizzes.

Originally, we also required a participation in the Discussion Board exchange (posting remarks, feedback, questions etc.) but as many students did not want to participate or had nothing to contribute, we dropped this requirement.

All module elements had to be in place by Release Week Monday. Where partner input was lacking at this point (or reasonably before), UBHAM existing material was inserted instead, thus allowing the students to complete their studies as planned. This concerned modules C1, C5, O2, and O3. Partners were of the opinion (though informed many times this was not so) that lectures would need to be delivered by the timetabled date, not noting the needs of online teaching which require considerable preparation well before due dates.

The programme was now 'ready to use'. Any overhauls prior to the next delivery of the programme would be conducted pending the outcomes of the partner peer review and feedback from students, as well as observations made by the teaching staff. One element of online teaching is that it is very easy to continuously update and add material. Insofar some thought has to be given to the amount of material students are confronted with and how this translates into engagement hours.

Table 1 shows the modules offered to these students in the academic year 2021/22. This was a reduced selection of exactly 12 modules so that no module options were offered. This was done in order to reduce the number of modules to be implemented by the start of the programme, thus allowing an initial full implementation for the students and mitigating the risk of missing input from partners.

The modules for 2021 (C1 to C4, plus C7) were already partly re-worked in view of the first feedback received from the CPD courses run in 2021. Module C3 (Hydrogen and Hydrogen-



based Fuels) was developed as a structural blueprint, whose format was then adopted for all following modules.

Table 1: Modules offered in the academic year 2021/22 TeachHy MSc programme at UBHAM.

Section	No.	Title
Core / Mandatory	C1	Introduction to Electrochemistry
	C2	Fuel Cell Technologies and Applications
	C3	Hydrogen and hydrogen-based fuels
	C4	Fuel cell modelling tools and control
	C5	Characterisation methods
	C6	Fuel Cell and Hydrogen Lab
	C7	Principles of Hydrogen safety
Optional / Elected	O2	Low temperature fuel cells
	O3	High temperature fuel cells
	O5	Advanced electrochemical characterisation
	O8	Fuel cell electric vehicles
	O10	Energy systems and storage

Every module was timetabled to take place in a single, full week ('short and fat' format) so that modules would be spaced by approx. one or two weeks with sufficient time in between for students to complete any coursework and prepare for the next module.

## 2.2 Test run Birmingham

With the programme start on 27 Sept 2021, we originally started with all five students. One student then withdrew, one changed programmes to part-time (i.e. distributing his learning across two years), and one had to take leave due to visa issues.

Delivery was according to the curriculum in Table 1 and the details set out above.

Although Semester 1 (27 Sept 2021 to 21 Jan 2022) was started in 'in person' mode, due to the Covid situation around Christmas, the university decided to go back to online teaching for Jan 2022, including all exams (which were now held online only). The impact on the MSc programme delivery was minimal, as all TeachHy modules from the start were designed in 'Flipped Classroom' mode.

2 students fulfilled all requirements and finalised their studies in 2022.

## 2.3 Other trial implementations

### 2.3.1 Trial at Grenoble INP-UGA

In the Master and Engineering course in Grenoble INP-UGA, in 2021, 37 students were enrolled in the first year and 31 students in the second year: Master-GECS, (Génie Electrochimique pour la conversion et le stockage d'énergie) and engineer-EPEE (Electrochimie et Procédés pour l'énergie et l'environnement). Since 2018, in those courses several modules exist which address FCHT issues.

Slides from TeachHy modules have been used in face-to-face teaching. This concerns lectures from modules C4, O2 and A1 (Advanced Electrochemistry). Currently, 1<sup>st</sup> Year students attend the Grenoble INP modules "Fall semester: Electrochemical conversion" and in second year: "Hydrogen carrier" and "Interfacial electrochemistry". An optional module is offered for Masters and Engineering students enrolled in the energy and nuclear programmes.

Recorded lectures are used to complement the face-to-face teaching for the first year of the Masters course: students learn the content through the recording and the main elements are repeated in class and tutorials are proposed face to face (flipped classroom). It concerns lectures from module C1 used in 2 modules of the Grenoble INP course: "Fall semester: Electrochemical kinetics" and "Spring semester: Electrochemical methods".

For the practical part of course, we have supervised laboratory-projects led by students (group of 4 students for each project) from September 2021 to January 2022. Those projects correspond to 4 ECTS point projects in the 2<sup>nd</sup> Year of the Masters course.

Teachy content from module C1 has been used in a "mastère" programme proposed by UTMB (Université de Technologie Belfort-Montbéliard) in module UV2: "Hydrogen production". The level of a "mastère" is Masters plus one year. In October 2022, the topics presented by Marian Chatenet were "Introduction to electrochemistry for electrolysis" (4 h, lecture course) and "Proton Exchange Membrane electrolysis" (6 h, lecture course).

Table 1 shows example learning outcome definitions used in these courses.

### 2.3.2 Trial at POLITO: remote laboratory

In the year 2021/2022 Politecnico di Torino supervised the SOFC remote laboratory for the students enrolled at UBHAM. The remote laboratory was attended by 2 students from UBHAM in January 2022. Slides from the C6 module of the TeachHy programme were used.

The slides describe the remote test bench (purpose, hardware and software), the remote-control interface the students use during the laboratory project, the experiment the students perform, and the requests for the analysis of the results recorded during the experiment.

Slides describing equivalent-circuit fitting methods for the analysis of the experimental results were also made available to students as supplementary materials.

Table 2: Examples of learning outcomes for Grenoble electrochemistry modules.

Title	Objectives
Characterisation of oxygen reduction catalyst of a PEMFC using gas diffusion electrode (GDE) cell	To improve the understanding of a new experimental set up. To propose test protocols
Glucose electrolysis studied by Differential Electrochemical Mass Spectrometry (DEMS)	To discover a method of characterisation To conduct a parametric study of DEMS determinations during glucose oxidation/reduction
Design of test bench for PEMFC	To set up a hydrogen fluidic control line to feed a PEM single cell To measure electrochemical performance of fuel cell

The remote laboratory has been structured first in a recorded introductory lecture, in which the laboratory is presented. A single cell polarisation test (SOFC, ESC cell) at different temperatures and hydrogen concentrations at the anode was the experience selected. Then, the personnel of Politecnico di Torino executed the physical preparation of the experimental test bench (cell mounting, heating-up to operating temperature, anode reduction and activation, first polarisation check) and provided the secure credentials to the students from UBHAM to access the bench interface the day of the laboratory.

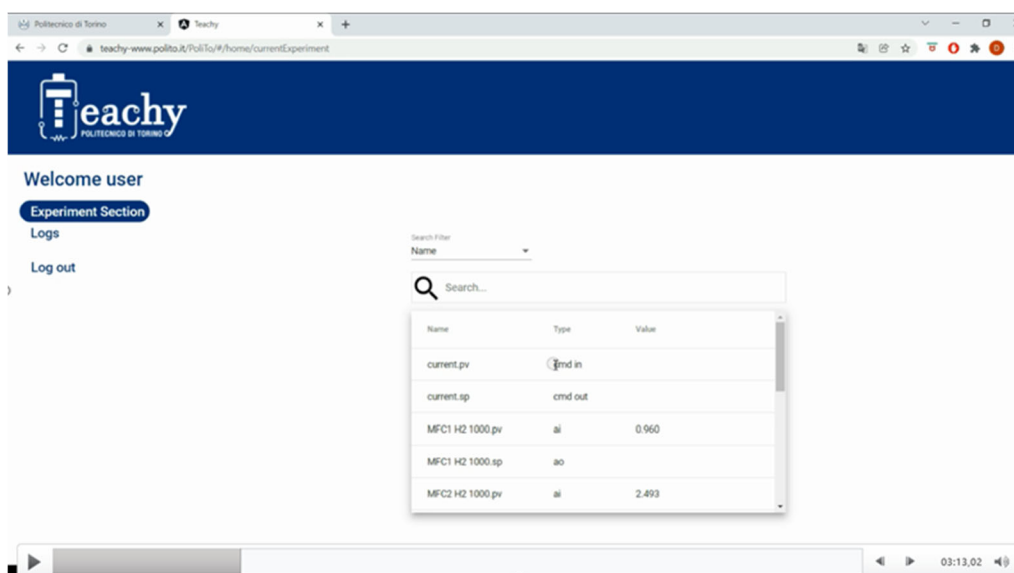


Figure 1: POLITO remote lab student web interface.

The supervised laboratory lecture consisted in the execution of the polarisations experience by the students supervised by Politecnico di Torino and UBHAM connected through a remote classroom. Polarisation was successfully performed by students, who collected the data and performed the analysis by plotting polarisation and power density curves and

executed calculations of FU, AU, ASR and qualitative analysis on OCV trend with temperature and concentration.

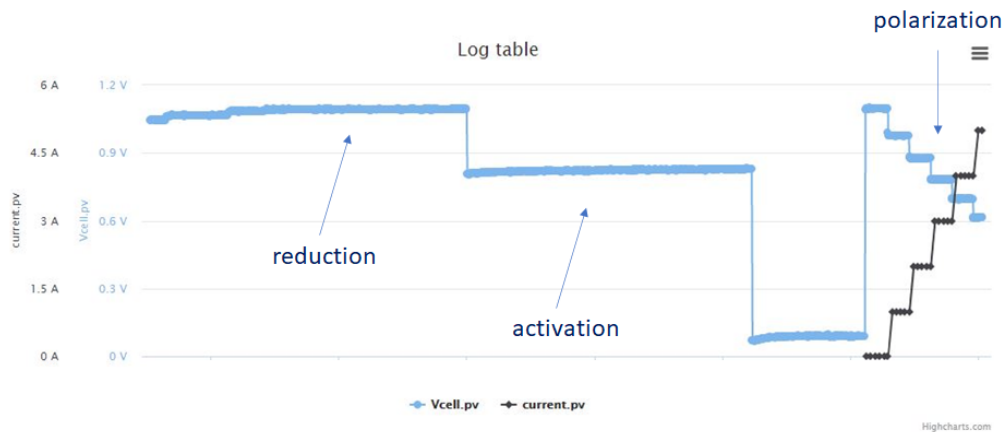


Figure 2: Datalog graph from cell preparation and first polarisation execution.

Following this successful test, the material and approach was adopted for regular use in the TeachHy MSc programme at UBHAM.

### 2.3.3 Trial at UPB

UPB tested part of the content of the TeachHy modules in its own master's courses, with two groups from the Faculty of Energy. Parts of the modules developed within the project and translated into Romanian were disseminated to the students, then their reaction and feedback was analysed. At the same time, the students were informed about the existence of this project and its purpose.

### 3 Summary Conclusions

Trial runs of TeachHy materials have been conducted at several consortium partners.

Nevertheless, the only full programme implementation and programme delivery was obtained from the UBHAM trial run started in Sept 2021. Although a number of initial students pulled out, the programme was delivered in full. It is suitable for a degree programme.

A wealth of feedback was collected from the trails and the CPD courses run in parallel in the years 2020 to 2022. This material was used to upgrade and improve the programme for the 2<sup>nd</sup> delivery at UBHAM fro 26 Sept 2022.