



A new Master Course in Applied
Computational Fluid Dynamics

FINAL METHODOLOGY REPORT

WP2.4 Description of methodology and tools



Co-funded by the
Erasmus+ Programme
of the European Union

Project Information

Project Acronym:	APPLY
Project full title:	A new Master Course in Applied Computational Fluid Dynamics
Project No:	609965-EPP-1-2019-1-TH-EPPKA2-CBHE-JP
Funding Scheme:	Erasmus+ KA2 Capacity Building in the field of Higher Education
Coordinator:	Chiang Mai University
Project website	www.apply-project.eu

Document Information

Author:	Universitat Politècnica de Catalunya
Reviewer:	Vellore Institute of Technology & Manipal Academy of Higher Education
Status:	Final
Dissemination Level:	Public

Copyright © APPLY Project



This deliverable is licensed under a [Creative Commons Attribution-ShareAlike 4.0 International License](https://creativecommons.org/licenses/by-sa/4.0/). The open license applies only to final deliverables. In any other case the deliverables are confidential.

Disclaimer:

With the support of the Erasmus+ Programme of the European Union. This document reflects only the view of its author; the EACEA and the European Commission are not responsible for any use that may be made of the information it contains.



Table of Contents

EXECUTIVE SUMMARY	4
1. INTRODUCTION	5
2. THEORETICAL SESSIONS	5
3. PRACTICAL SESSIONS	6
5. TUTORIALS	7
6. LITERATURE REVIEW	8
7. ASSESSMENT AND SUMMATIVE FEEDBACK MECHANISMS	10
8. CASE STUDIES	10
9. PROJECT BASE LEARNING	11
10. INDUSTRIAL VISITS	11
11. PRESENTATION AND WRITING SKILLS	12
12. USE OF A SECOND LANGUAGE	12

Executive Summary

This report explain the principal methodology and tools which will be followed by the lecturers of courses. These guidelines will be used in the following work packages (WP2.5 & WP3) in order to create a proper curricula.

Copyright © APPLY project



This deliverable is licensed under a [Creative Commons Attribution-ShareAlike 4.0 International License](https://creativecommons.org/licenses/by-sa/4.0/).

1. Introduction

APPLY's Work Package 2.4 (WP 2.4) is devoted in developing the methodological approach of the Master's programme. Methodology refers to the practices that will be used during the courses in the different general contents. The topics to be covered are the following list, together with the institution in charge of its development:

- Theoretical sessions
- Practical sessions
- Online sessions
- Assignments
- Tutorials
- Literature review
- Examination and related issues
- Case studies
- Project base learning
- Visits to industries
- Communication skills
- Use of a second language

Even though the lead partners are the ones that will develop the main methodology of each course, the wider group is expected to further adjust these and adapt them according to the local delivery requirements.

2. Theoretical sessions

During the theoretical classes, the basic theory and concepts of the subject matter will be delivered. Support material will be also available in the form of a presentation that will be followed during the class, a paper that will be followed or any other source. Material made by the lecturer has to be clear and the main ideas should be easily visualized by the students. The class should start asking the students if there is something that was not clear from the past sessions. This will keep the class focused on the new contents without misunderstandings. This action will enforce the students to not hesitate asking question during the lectures.

During the lectures, the lecture must stop occasionally to let the students ask questions about the contents reviewed. Also, these pauses can be used to ask questions about the main ideas developed during the lecture and especially in the most difficult ideas that can produce misunderstandings. Abstract ideas, not easy to grasp or confusing (many examples can be found in CFD), have to be clearly explained in order to not lose the attention of the students. The lecturer should not hesitate to stop multiple times and ask the students to make sure that they are actually following the contents.

In the case of online courses, the interaction with the students in theoretical sessions is especially difficult, as the students tend to ask less questions. Therefore, the lecturers have to be very careful to ensure that they have the attention of the class. It is important to leave enough pauses between lectures. We recommend that



the students have their video cameras on, if this is possible, in order to provide a visual feedback to the professor.

3. Practical sessions

The practical classes can be done as problems sessions, individual assignments and group assignments.

- Problem sessions should be used to illustrate key concepts by means of practical exercises. These exercises have as main purpose to reinforce the contents delivered during the theoretical sessions. They must be short and relatively easy so they focus on illustrating the concept, rather than introducing new ideas. These exercises can also be done during the theoretical sessions between the different contents of a lecture, to reinforce the knowledge explained just before.
- Individual assignments can be carried out in class or as additional work for the student. It is strongly recommended to use a combination of both: use the class as starting point of the assignment, to solve general doubts that the students may have and then let them finish it in a programmed time. During the sessions devoted to the assignments, it is advisable to solve the general doubts for all the attendants, as most of them will have common problems. Then, allow some time to solve the minor doubts individually as they can be very specific. Addressing the general doubts in front of all the students will improve the understanding of all them, as something that maybe is not completely clear will be explained again or it will start new discussions that can be interesting.
- Group assignments can be carried out in the class or as additional work for the students. It is advisable to allow the students time to work in small groups during the classes. Experience shows that in this way, the students feel free to discuss openly their difficulties with their pairs.

Long group assignments can be considered as team projects that combine different parts of the subject. At least a part of these longer assignments can be left quite open, allowing free development to be carried out by the students, who will identify and solve interesting challenges. A possible idea is to divide the assignment in two parts. In the first part, a closed problem with a concrete answer is given, and in the second, each group has to find and solve an extension or an application example. The lecturer should promote the cooperation between the groups, for instance, to ensure that all of them have the same result for the closed part, allowing them to autocorrect their own mistakes. Then, in the second part, the different groups try to find the most interesting application examples. As a general rule, the lecturer should orient the students and solve their general doubts, but also allow them to experiment and try to work as in a real situation.

At the end of the group assignments, it is a good practice to allow to present their work in front of the class. All the students should be allowed to ask questions, and submit to the professor a report with their comments about all the works. The comments should be used to evaluate the mark of the group making the comments, not the groups receiving it. This helps all the students to keep their focus during the presentations and to learn how to express their point of view respect to the work of a pair.

Formative feedback mechanism:

After the submission of the assignment and its correction, it is recommended to discuss the solution with all the class (or in smaller groups), highlighting the most common errors as well as the best solutions. The students must have the opportunity to defend their work and compare it with the reference solution. This feedback, while not part of the mark, has to be considered a very important step and a key element in the learning process. For the group assignments, a part of the mark has to be assigned to the presentation and to the quality of the comments respect to the work of other groups.

4. Online sessions

For each course, each university will decide which part of the course will be done online. The online sessions are to be carried out following the previous guidelines. However, some specific points have to be stressed:

- It is especially important to ensure a good feedback from the students, encouraging them to interact with the professor. Otherwise, the sessions can be a waste of time.
- If possible, it is far better if the students have their video cameras turned on. This allows the lecturer to see their reactions.
- The lecturer has to make more pauses and ask more questions to the students in order to keep their attention.
- For the practical sessions, a good practice is to have separate sessions (one per group), in addition to the main group. The professor (or professors) can use the break-out room functionality available in most online meeting platforms to create student groups visit these groups to take questions and discuss key findings. This way, the practical online sessions can be even more productive than their equivalent presential sessions (where it can be hard to keep each group focused on their own work, as there is crosstalk between the groups).
- In general, it is better to have more practical sessions in online lectures.

5. Tutorials

Tutorials speak to an active learning ethos and all variants of small group learning environments where active interaction refines thinking, reflects attitude and revolutionizes the problem-solving mindset. Tutorials are written to address student misconceptions and topics that are particularly challenging to students “scaffolding student learning”¹. They may offered in different modalities including:

- Discussion-based, focusing on a deeper exploration of course content through discussions and debates,
- Problem-solving, focusing on problem solving processes and quantitative reasoning,

¹ 24. Carleton College. 2019. Teaching Methods. A Collection of Pedagogic Techniques and Example Activities. What are lecture tutorials? [Accessed January 2021]
https://serc.carleton.edu/NAGTWorkshops/teaching_methods/lecture_tutorials/what.html

- Review and Q/A where students ask questions about the course content and assignments with a view to consolidate their learning in the guiding presence of their instructor or teaching assistant.

Given the interactive nature, a tutorial should be carefully planned. They should have their own learning goals and clearly define what students will do while encouraging active learning. Guidelines should be present at the very beginning defining how the tutorial will run. Special consideration should be given to online tutorials. More specifically:

- Students should be informed about the online tools employed (what and how),
- For tutorials offered in synchronous mode, the timeline and the participation rules should be early communicated to the students,
- For tutorials offered in asynchronous mode, the problems or discussion prompts with clear participation instructions again should be early communicated.

Tutorials are one of the most important procedures to make students learn by doing and it is the tutor's or instructor's role to establish the environment in which this can occur.

6. Literature review

A literature review is a search and evaluation of the available literature in a given subject or chosen topic area. It documents the state of the art with respect to the subject or topic written about. A literature review has four main objectives. These are as follows ²:

- To survey the literature in the chosen area of study
- To synthesise the information in that literature into a summary
- To critically analyse the information gathered by identifying gaps in current knowledge; by showing limitations of theories and points of view; and by formulating areas for further research and reviewing areas of controversy
- To presents the literature in an organised way

A literature review shows the reader that the student has an in-depth grasp of the chosen subject and that they understand where their own research fits into and adds to an existing body of agreed knowledge. In addition, the literature review:

- Demonstrates a familiarity with a body of knowledge and establishes the credibility of the student's work;
- Summarises prior research and says how current work is related to it;
- Integrates and summarises what is known about a subject;
- Demonstrates that the student has learned from others and that their research is a starting point for new ideas."

² 21.Royal Literary Fund. 2020. What is a literature review? [Accessed January, 2021]
<https://www.rlf.org.uk/resources/what-is-a-literature-review/>

- Is a critical and in-depth evaluation, and is not an inventory of all previous research in a field but an assessment of previous research or writings that should also identify shortcomings and gaps in knowledge³

A literature review not only summarizes the knowledge of a particular area/field/study but it also evaluates what has been done and what still needs to be done. The structure and size of a literature review varies according to the different types of thesis/essays and disciplines. It is common for postgraduate students after developing their research proposal and defining their research statement to develop their literature review section. In general, a literature review can be:

- A stand alone- individual document e.g. in-depth review articles which can be valuable for researchers and experts;
- A section within a document i.e. being part of dissertations, theses and research reports.

The following figure summarizes the general steps constituting the whole process.

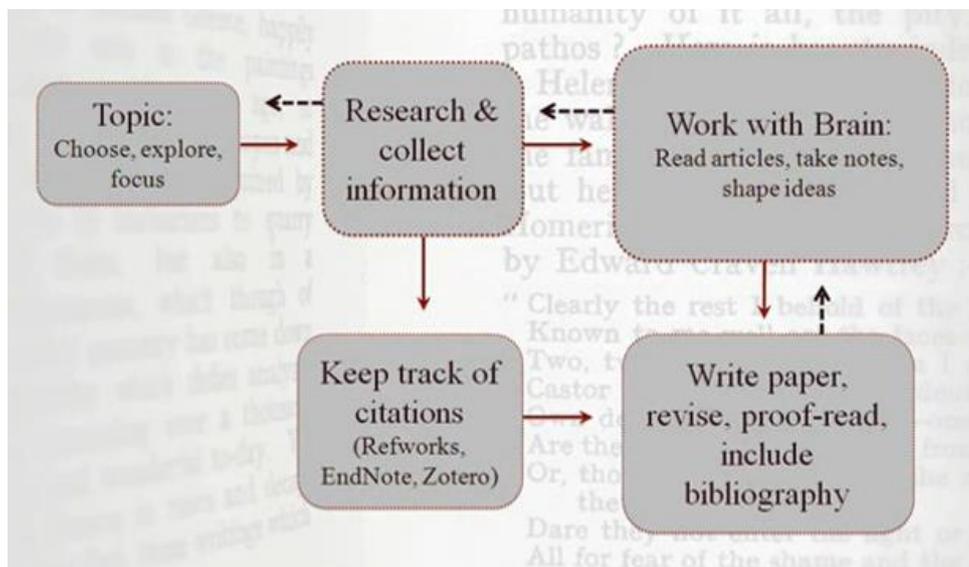


Figure 1 Source: North Carolina State University. (n.d.). Literature Reviews: An Overview for Graduate Students. <https://www.lib.ncsu.edu/tutorials/litreview/>

³ 22.Stokes, D. 2017. What is a literature review? UCD Library Guide. [Accessed January, 2021] <https://libguides.ucd.ie/litreview>

7. Assessment and summative feedback mechanisms

As part of APPLY's course descriptors the assessment and summative feedback mechanisms that are envisaged for each individual course are reported. A variation of assessment mechanisms is envisaged ranging across conventional in-class closed book or partially closed book examinations, to open book synthetic assignments. These are dependent on the nature of each individual module and are described in detailed in the deliverable report of WP2.5.

In terms of summative feedback, this will be dependent on the selected examination mechanism of each individual course. The virtual learning environment (VLE) will facilitate online marking and administration of the results. In the cases where more than one types of examinations are envisaged for a certain course, i.e multi-part exams, these will all be marked on the VLE and the final score will be automatically consolidated based on the assigned rubrics. For further details on individual course envisaged assessment approach please refer to WP2.5 deliverable report.

Additionally, the courses will require a formal feedback from instructors and students during the end of the semester. This feedback must focus how the course is delivered; including course content, course materials, invited lectures, industrial visits, methodology followed, projects proposed and all the related course structure characteristics. Moreover, quality assurance meeting between instructors and students representatives should be conducted in regular intervals (twice per semester for instance) to enhance the teaching learning process. Alternatively, students could be encouraged to pursuit feedback meetings with the instructors during the courses if the numbers allow it. A provision has to be enabled to quantify the attainment of course outcome upon completion of the course. Based on the feedback received, teaching methodologies and tools should be revised.

8. Case studies

Case studies are a very useful pedagogical tool in any undergraduate or postgraduate course, as a complementary way of teaching. A case study is an effective classroom technique, aimed at gaining concrete, contextual, in-depth knowledge about a specific real-world subject, by gathering information, analysing related data and presenting the findings. It allows students to explore the key characteristics, meanings, and implications of the case. They are particularly appropriate and useful when teachers want students to explore how the provided knowledge applies to real world situations and develop a mature understanding of complex flow physics while also covering the range of concepts essential for successful use of CFD.

Students may use just one complex case study where they explore a single subject in depth or conduct multiple case studies to compare and illuminate different aspects of the research problem at hand. Moreover, case assignments can be done individually or in teams of varying sizes, or on a whole class basis so that the students can brainstorm solutions and share the workload. Critical analysis and evaluation of a case study trains students in critical evaluation and in making decisions and defending them to a group, focuses on practical examples, allows them to share their own work experience and ensures retention of lessons learned.

Some of the advantages of such method of learning, in the research field of computational fluid dynamics are:



- Deep understanding of the physical or/and mathematical aspects of the assigned subject, particularly in the field of CFD, that would be impossible to teach in a one-semester course.
- Introduce students to research techniques and acquire useful skills in bibliographic review.
- Hands-on experience with computational fluid dynamic models and algorithmic techniques.
- Opportunity for the students to solve an applied problem, using widely used commercial and/or open source software tools.
- Application of theoretical knowledge of grid generation into real-life geometries and applications.

Moreover, the assignment of a case study to the students will built their abilities to compose a structured academic report, analysing the findings of their case study and exploring similar cases from the literature. A detailed presentation of the case study should also encourage the students to improve their communication skills and learn how to present their ideas and results of their research in a structured and organized way.

9. Project base learning

Technological progress coupled with a shift in the demographic profile empowers young engineers to productively engage in the spirally expanding manufacturing and service sectors. This, however, requires a thorough overhauling of the higher education sector including advanced tenets of CFD applications.

This International Masters Programme in Advanced CFD is structured so that the Graduands receive a holistic grounding in theoretical as well as practical applications. The latter must involve procedures that are customized so that the students are able to grasp techniques in a real-world situation. This is best achieved through Project Based learning. We suggest this be adopted in many of the Core as well as Elective modules.

Although the project method is initially teacher-led, it is a student's mainstay thereafter. The student is allowed to freely acquire and apply knowledge to solve real-life problems using a process of 'extended inquiry'. Chosen CFD Projects must be student-centered, following standards, parameters, and milestones clearly identified by the faculty.

It is suggested that each assigned project within a module have 3 assignments and a final project report. These should have the potential to be developed into conference papers nationally as well as internationally. Exceptional ones may be developed into a full-fledged research paper handled by a Faculty.

Finally, it is important to note that it is suggested that it is better to have PBL/RBL options for only 20% of the courses in mainly the elective courses.

10. Industrial visits

Visit to the Industries must complement taught modules on CFD applications in real life situations. Most manufacturing processes include patterns of flows-Flows encountered in energy and momentum transfer as well as material transport processes. The partner countries within this programme have either assembly lines or direct manufacturing units of automotive parts along with entire assemblage facilities for variety of vehicles. Fluid flows in chemical processes are ubiquitous-co-flows in petrochemical industries, slurry handling in building industries and other processes. Whilst the taught modules laboratory modules, project based modules provide the background knowledge of CFD applications, only a site visit consolidate the learning

experience through a direct perception of challenges involved. It is proposed that there should be two industrial visits one at the end of the first year to enable the students to choose from a variety of industrial processes that subsume CFD applications and another at the end of the third semester, just prior to the commencement of their thesis work. This shall be an enabling experience with crucial inputs from industrial experts during research explorations for the thesis. Last but not the least, industrial visits lead to networking and collaboration essential for future placements and job opportunities.

Industrial visits are also necessary to enable students to seek opportunities for a full-fledged internship. Additionally, full-fledged thesis work in some cases could be undertaken on site, particularly when the research is industry sponsored.

11. Presentation and writing skills

Communications Skills are required to disseminate outstanding outcomes-be it a novel algorithm, a novel design concept or even a new research result. A short course on effective communication skills will be included in the Masters Programme in the Final stages of the curriculum, but preferably just prior to the stage of Thesis preparation. Communication skills subsume both oral as well as written skills in English. The following pattern might be used in the instructions:

1. Writing an Abstract. This is an important part because a good abstract sets the scene for what shall follow. For a CFD based work, the first few lines must comprise a description of the remit of the study. This should be followed by a discourse on the study's relevance. The key methodology must then follow with an account of the most significant research results and outcomes.
2. A discourse on grammar and writing styles. The use of software to edit English writing and test plagiarism.
3. Writing up Research results so that the writing is impactful and not dull and repetitive.
4. Use of Latex for mathematical typesetting-in a CFD programme this will a good life skill to takeaway and is included in communications skills because an equation's import needs to be spelt out in the best possible means to a numerically literate audience in academia.

5. Oral

Skills

Basic lectures should include methods of good delivery. They must learn how to sieve useful information from redundant information and should be able to customize a speech suited to the need.

The following points are important:

- They should be taught how to defend their thesis in the presence of a select committee prior to the Final Viva. This will enable students to learn from a first-hand experience
- They must be taught the basic tenets of customized speeches suitable for local community as well as for the Industry and the corporate world. For example, if the student has developed a unique protocol or a piece of CFD software, they must learn how to market it within a limited time period-they must be taught how to pitch an 'Elevator Speech'.

It is suggested that during the 3rd Semester, a 2-day Training Program in a specialized workshop where Communication Skills will be offered by experts.

12. Use of a second language



This second language is optional and country specific. For the Malaysia and Indian Subcontinent English is not treated as a foreign language, however, a few European languages along with some South Asian and Asian languages are viable options. Depending on the progression plan of passing out students, a considered suite of second languages could be made available.