Time2Go4.0

Collaborative Blended Projects for
Top Industrial Managers
in Sustainable Industry 4.0

How to ensure quality of preparation and execution of collaborative blended design projects including 4.0 and sustainability aspects?

Some guidelines

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T.I.M.E. Top International Managers in Engineering

Time2Go4.0

Collaborative Blended Projects for Top Industrial Managers in Sustainable Industry 4.0

How to ensure quality of preparation and execution of collaborative blended design projects including 4.0 and sustainability aspects?

Some guidelines

1. Introduction

Design projects are recognized as an excellent learning activity to develop synthesis, autonomy and work organization skills. In the field of product or machine design, it involves many aspects such as identification of market needs, definition of specifications, generation of proposals, multicriteria decision, graphical communication through CAD software, dimensioning, revision of solutions due to manufacturing, assembly and cost constraints, … The amount of work is especially demanding if a realistic detailed design is expected, as in a real industrial situation.

Such complex tasks benefit a lot from a collaborative work in teams where experience and ideas may be exchanges and skills shared.

The training of engineering students with respect to product design and management of production systems is challenged with technological and societal breakthroughs:

- industry 4.0 has induced fundamental changes into industrial practices, regarding performance of their assets;
- the sustainability development objectives have emerged as the major worldwide outcome; they are integrated more and more in the engineering curricula.

Project-based learning in engineering is not new: most of product design projects still rely on a strong “classical” technological basis (selection and dimensioning of elements, manufacturing constraints, performance analysis, …). Multidisciplinary approaches for complex systems have emerged to include additional aspects as market analysis, industrial design, team management in the concurrent design process.

Internationalisation of research and development activities have shown the interest for blended activities where some tasks are performed at distance, some others during face-to-face meetings.

The teaching methods have been turned upside down with the coronavirus pandemic: project-based learning with distance constraints has demonstrated limits but also a new perspective with the need to be more focused on this mode of interaction as telework will not be the exception from now.

The T.I.M.E. association has supported a common projects between a consortium of universities that are engaged to develop these collaborative 4.0 design projects for sustainability involving their engineering students.

Figure 1. Time2Go4.0 consortium. Will your institution join us?

2. Mechanical design projects

The scheme of the product design process led by the students follows the main lines of a design project as defined by Pahl, Beitz and Feldhusen [pahl2002], Ullman [ullm2009], or VDI 2221 and 2222 guidelines on Systematic approach to the development and design of technical systems and products (Figure 2).

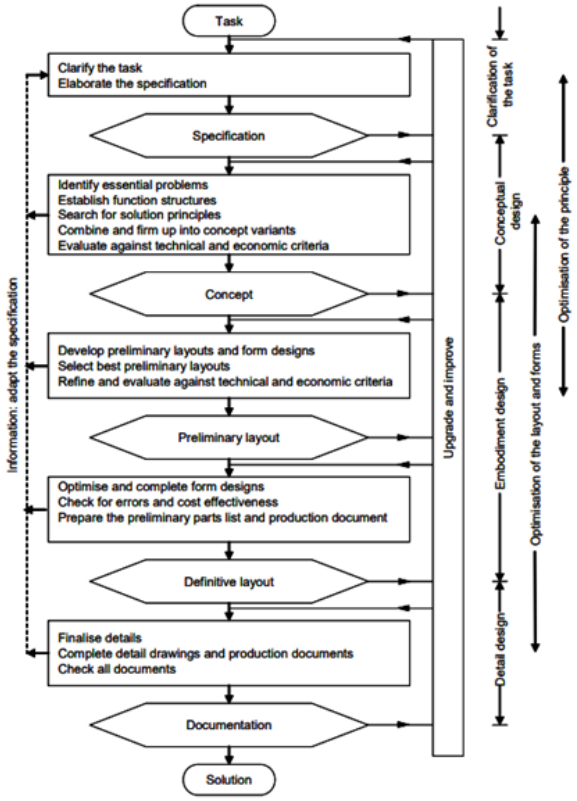

Figure 22. Design Guideline VDI 2222. This scheme has been replaced by VDI 2222 to include "modular design" (refer to [jans2006])

It is expected that a group of students perform all the design steps for a product: identification of the needs, defining functional specifications, proposing a conceptual design after analysis of different variants, achieving a detailed design. The final deliverables are a technical report justifying the selection of parts and their dimensioning and drawings with a full bill of materials. Manufacturing and assembly constraints are taken into account.

The VDI design guidelines are commonly agreed by the design practitioners and many variants are documented ([Tomiyama 2009]). More modern global approaches making are encouraged to develop new engineering skills, as discussed during a Workshop held during the General Assembly meeting of the T.I.M.E. association ([Chen 2022]), as illustrated by Figure 3.

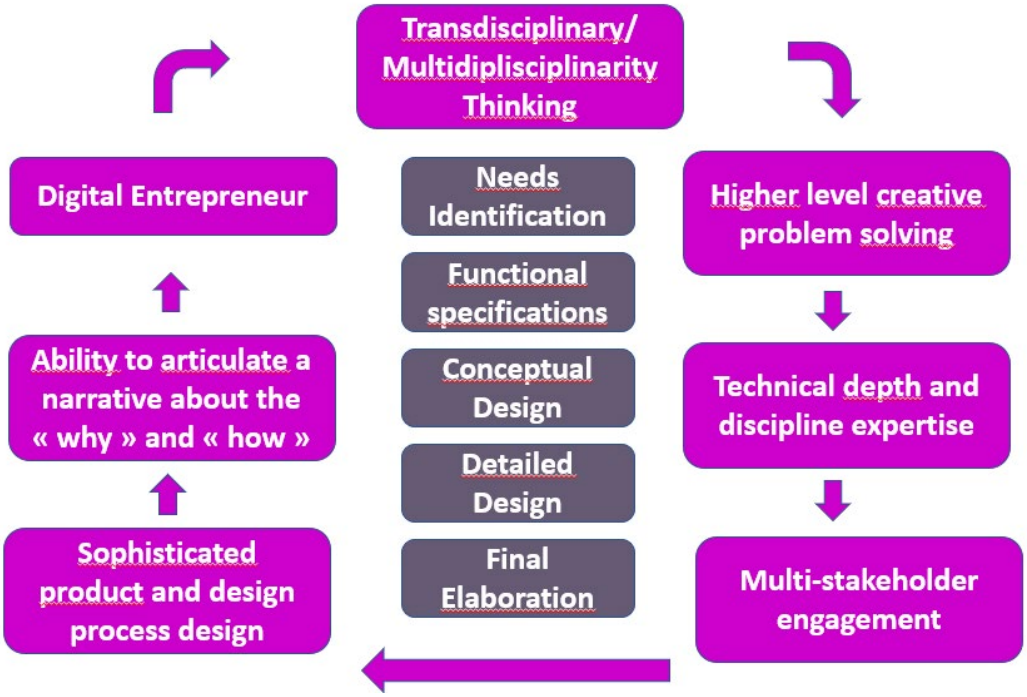

Figure 3. New engineering skills (adapted form [Cheng 2022]) around the design steps.

Such a design project requires time and effort and is led during a whole academic year. Some partial contributions limited to a semester could be possible (business, design, sustainability estimation) but are not encouraged to keep the involvement of the whole team. To keep students motivated, supervision will be provided, and most partners agreed to award credit points for students upon successful completion of the project.

Different examples of design projects have been shared among the Time2Go4 members (Figure 4). Some are included in the curriculum, while some are not systematic (Bachelor's or Master's thesis).

Figure 4. Design projects currently led among the Time2Go4.0 institutions: CAD models, prototypes and real products

In this perspective, the product should have a sufficiently wide market to enable an economic analysis. Up to now, the discussion about the necessity to get a subject from an industrial partner is still open. A subject form the industry will be well documented and supported, but subject to non disclosure constraints.
In the current views of the project, prototyping is not included in the project definition.
The CDIO approach (abbreviation for "Conceive Design Implement Operate") ([craw2010]) is inspiring. As the implementation (transformation of the design into a real manufactured / assembled product) will not be a priori realized during the timeframe of the student project, the CDIO approach will not be applied rigorously.
Creativity will be developed and assessed according to the Creativity Rubric proposed by UPM ([mart2015]).

Different skills are expected to be developed by the project activity:

Technical skills for mechanical designers:

- Technological vocabulary
- Design methodology
- CAD drawing and assembly
- Machine element selection and dimensioning
- Integration of manufacturing and assembly constraints
- Numerical simulation
- Complex decision at conceptual and detailed design stages

Soft skills for mechanical designers:

- Project management
- International teamwork
- Communication and leadership
- Ability to discern the limits of own skills and to call on expert subcontractors
- Intellectual property awareness

3. The collaborative, multidisciplinary, international dimensions

a. Introduction

Blended learning is a deliberate mix of face-to-face and distance-based on-line activities, with the goal of stimulating learning and overcoming organizational constraints especially when frequent physical meetings are not possible due to distance constraints.

According to Boelens *et al.* (2022), there are four key challenges to designing blended learning:

1. flexibility (control over time, place, path, or pace of learning);
2. interaction, despite of the transactional distance linked to an enlarged psychological and communication space;
3. self-regulation of students' learning processes, requiring different skills: organization, discipline, time management, ability in using different communication channels;

4. affective learning climate: showing empathy, having a sense of humor, providing encouragements, directing attention to task-relevant aspects, and attending to students' individual differences.

Such groups of people who interact mostly through online tools and very rarely meet in person [Miller 2012] are referred to as Virtual teams and are more and more widespread in the professional world. It is then important that universities involve their students in experiences allowing them to develop the competences required to properly operate in virtual teams. Over the usual issues related to team work, virtual teams are confronted to specific difficulties which must be managed. By nature, virtual teams exhibit a large professional and cultural diversity: it is one of their advantages as diversity is known to provide better decisions and more innovative results, but it is also a source of conflict if the team cannot reach a shared team mental model [Krawczyk 2016, Zuofa 2017]. Global (worldwide) virtual teams may have incompatible working hours. The lack of physical and social interaction deprives virtual teams of non-verbal communication and emotional context to the detriment of efficient collaboration and trust construction. Control and monitor require more effort. Various levels in English which is the natural lingua franca of virtual teams [Räisänen 2020] may lead to misunderstandings or isolation. Depending on the countries, virtual teams can be spoiled by technical problems: bad sound, inefficient tools, unreliable network.

Before involving students in virtual teams, it is primordial to be conscious that they have specific needs: most of the problems encountered by localized teams are just exacerbated in virtual teams and can be solved by following still more carefully classical management rules [Krawczyk 2016, Verburg 2013, Zuofa 2017]: early establishment of operating and communication rules, clear communication, clear distribution of tasks and responsibilities, project monitoring, commitment control, regular feedback, building respect and trust. Secondly, participants must be prepared to cultural diversity and multicultural communication so as to develop team spirit and trust. Thirdly, a proper environment must be provided, among which efficient computer communication tools and infrastructure. For the usage of synchronous and asynchronous computer-mediated tools (instant messaging, email, chat rooms, online forums, social network services, …) [Thurlow 2004], training is welcome as skills and knowledge in information and communication technologies (ICT) are often overestimated [Kolm 2021]. Regular synchronous meetings are recommended [Kolm 2021] and ideally some face-to-face meetings [Zuofa 2017], especially at the beginning of the project.

b. Project organization requirements

i. Management of partners

The implementation of such an international student project basically involves several universities referred to as partners of the project. Some external partners (companies, public institutions, …) can possibly actively contribute to the project. All these partners must

collaborate and must be aware that they are actually also involved in a virtual team. It is then important that they apply to themselves what they expect from the students.

- The tasks, their distribution among partners, the deadlines and the responsibilities must be properly identified.
- Clear operational and communication rules must be defined, ideally by agreement.
- It is necessary to induce respect, trust and common mental model in the teams.
- Partners must be aware of possible issues due to multicultural/multidisciplinary differences.

Objectives and general rules must be defined in the beginning of the project. Moreover, for each session, it will be necessary to

- define/collect tasks;
- fix calendar;
- recruit students;
- reserve accommodation;
- organize events (kick-off, closure, intermediary check points, …) with the type of organization (online/in person), a program, a list of speakers, …;
- prepare the evaluation process;
- prepare a quality plan (calendar, questionnaires, …).

ii. Project documentation

It is primordial that students involved in such a project have a complete information about the game they play. All students must be aware of the following items.

- Objectives and context of the project
- Who can participate ?
  Which hard (disciplinary) and soft skills are expected ? Are there prerequisites ? In particular, what is the minimum level in English ?
- Typical team composition: number of students, distribution of technical and non technical roles role.
- Rules of the game: evaluation, typical calendar with deliverables and requested outputs, contacts, communication channels and communication rules.
- Role and contact information of all stakeholders: teachers/supervisors, coaches, experts, local university contact, external partners, …
- List of available online resources: self-learning modules, glossary, templates, ...
- Selection of computer-media communication tools with tutorials, that all students can access through their university account, knowing that default solutions may differ among partners.

iii. Support

To complete their assignment, student teams need support. The following items are desirable

- ***Compulsary self-learning modules***
  Due to the specific nature of blended virtual teams, modules (or links to relevant ressources) must be offered in the following domains: project management, written and oral communication in English mutlicultural aspects, usage of computer mediated communication tools, usage of online collaborative tools.
  It is important that all students acquire a minimal awareness in these subjects. Ideally, webinars should be organized, completed by written documents and references. If it is not possible, a minimum information can be given during the kick-off. In any case, self-learning documents and videos are welcome, ideally along with an evaluation to verify that students acquired the minimum level.
  E-learning platforms (e.g. Moodle) offer a pragmatic platform to host the modules.
- ***Disciplinary modules***
  Although each student is expected to work in his domain, depending on the topic, he may need supplementary information with respect to his initial training, which will be provided by self-learning modules. It may also happen that the project requires training on a specific topic, out of the material covered usually in the programs of the student.
- ***Experts***
  Experts can issue from the academic or external partners. They are expected to answer questions in their field of expertise. Communication rules must be properly stated: mail, forum, ...
- ***Coach***
  It is recommended that each team has a coach. The coach is the first contact person and somehow the transmission belt between a student team and the supervisors. The coach should have regular meetings with the team manager. He must firstly listen to the team but may ask questions when necessary. When several evaluators are involved, it is interesting that the coach summarizes the remarks/suggestions and provides the feedback to the teams. For better trust, coaches shouldn't be directly involved in evaluation.

iv. Evaluation

Any teaching activity ends up with an evaluation which can be a simple pass/fail or a mark. If the evaluation is successful, the student gets the credits otherwise not. The main role of evaluation is to provide a reliable mark, taking into account the various expected learning outcomes among which we can cite in our case written and oral communication in English, team working (through online tools), international/multicultural aspects, professionalism, as well as specific skills related to engineering, project management, business/marketing, artistic design, … However, the evaluation process should also:

- naturally impose an appropriate pace;
- allow the students to improve;
- and allow to detect free runners.

The difficulty of evaluation of an international student project should not be underestimated as it involves all partners, is possibly multi-disciplinary and mixes individual and team aspects.

c. A practical proposal

i. Introduction

We propose here a typical organization largely inspired from the Erasmus+ MUPIC project, standing for MUltidisciplinary Project in an Industrial Context. The formula proved to be successful and can be easily adapted to similar projects.

ii. Constructing the consortium and preparing the student project

First of all a consortium of partners must be created involving several universities, each of them ideally issuing from different countries sufficiently far away from each other and with different different local languages. A consortium of 4/5 partners is a good compromise between diversity and complexity. Industrial or institutional partners can be associated as well, permanently or in function of the task proposed to the students. It is also important that all participants are familiar with computer media tools.

In any case, it is necessary to designate a general manager and a main contact per partner. Other roles can be defined: secretariat, web site manager, evaluation manager, support manager, finance manager (if project is funded) … The general manager will endeavor to implement the project management rules in order to fulfill the requirements listed previously: distribution of tasks (what ? who ? when ?, leader ?), communication rules, trust and team spirit construction, identification of possible multicultural issues,… Let us note that respect and trust are usually acquired by completing collaborative work so the importance of early missions involving several partners. Partners can move most of the project forward through asynchronous communication (typically e-mail) but online meetings are necessary to make decisions which need negotiation and exchanges. If possible, some in person meetings are welcome. All meetings discussions will be written down in minutes.

It is important that messages touch only concerned people: over communication induces fatigue and carelessness. A shared online drive is welcome so that all partners can rapidly access important documents like minutes of meetings, a list of tasks with calendar and state of achievement, check-lists, contact information, information to students, … All partners must be aware of possible issues due to multicultural/multidisciplinary differences. Possible issues or conflicts must be addressed knowing that no problem is unsolvable once properly identified.

Partners should agree as early as possible on some points in order to avoid later troubles

- the type of project: intellectual (provide documents), practical (provide prototypes), a mix of both, with or without external partner, ...;

- the domains in which contributions are expected (engineering, business/marketing, project management, design, …);
- the typical composition of a team (so as to ensure a blended international activity and usage of English);
- the profile and number of the students that each university can recruit;
- the profile and number of teachers who will be involved;
- the number of credits that each university can assign to students (as the task is cumbersome, students must receive credits; the number should be aligned with the amount of work expected from the student and vice-versa);
- a typical calendar: duration (one or 2 semesters ?), kick off and final events, number of intermediary check points (note that calendars can be rather different even on the same continent);
- the evaluation process (cf. later) and namely the deliverables and the list of requested outputs for each of them, in all concerned disciplines;
- the software tools available in each university and their possible compulsary usage (e.g. for text processing, simulation or CAD);
- the retained online platform (e.g. Moodle) for teaching support: documents hosting, forums, deliverables submission, …
- the support that will be provided to students: self-learning modules, references, coaches;
- the possible issues in terms of intellectual property, in case an external partner imposes confidentiality restrictions (e.g. NDA) to students and or teachers.

It clearly turns out that the project needs preparation and cannot be proposed to students immediately after the creation of the consortium. Besides the previous items, other things must be prepared: self-learning modules, information documents to students, web site, online course, ...

Besides these global items (valid for all years), specific actions must be taken each year before the execution of the student project

- define/collect tasks, possibly from external partners;
- define calendar with kick-off and final events, deadlines for deliverables;
- refine evaluation process (e.g. list of deliverables and requested outputs depending on the subject);
- recruitment of students;
- define the schedule of events and contributors: seminars, team activities and deliverables;
- reserve accommodation for in person events;
- prepare a quality plan (project evaluation by partners and students).

Some good practices can already be cited here

- Recruitment is easier and more reliable (well informed students are less prone to quit) if tasks, calendar and evaluation are available.
- Although it can be a brake for some students, a minimum level of English is necessary to avoid poor performance or member isolation. In MUPIC, a B2 level was required in MUPIC and seems sufficient.
- A team of 5 students is generally considered as a good compromise. It was admitted to be a good order of magnitude by MUPIC students during interviews and is in accordance with literature. With less members, the team becomes very sensitive to a student quit or a free runner. With more students, management and especially follow up become difficult. Adaptations can be made depending on the amount of work and the competences needed to complete the project (for example there were 2 students in engineering during MUPIC because the task defined by industrial companies was mainly related to engineering).

iii. Calendar, deliverables and evaluation

Calendar, deliverables and evaluation are strongly related. The calendar will impose the pace while the content and type of deliverables will ensure the acquisition of the targeted competences which the evaluation is based on. A typical implementation will include a kick-off event, a final event and some intermediary check points. It is usual that the kick off includes the presentation of stakeholders (organizers, experts, coaches, external partners,…), the presentation of the rules of the game (communication, evaluation, calendar,…), the documentation and tools available on the retained online platform, a presentation of the self-learning modules if any, student activities among which icebreaking ones to initiate team construction, and of course the definition of the task. The final event will be mainly devoted to the presentation of projects by teams but will be the opportunity for a bidirectional exchange between teachers and learners. Students will be informed of their strengths and weaknesses while teachers must collect feedback for further improvement. At the intermediary check points, students are expected to demonstrate the progress of the team, through reports, presentations or interviews. For all steps, it is important to clearly define the deliverables and the requested outputs.

During the MUPIC project, involving only European universities, the kick-off and final events took a week and were organized at end of september and mid-may. Three intermediary check points were imposed at end of october, mid-december and end of march. The requested outputs for each item are given in Tables 3.1 to 3.5. It is of interest to note that

- requested outputs are defined for each aspect of the project;
- deliverables include individual and team productions;
  the individual diaries concerned multicultural aspects, teamwork (good things, bad things, conflicts, role/involvement in team), personal development of soft skills (team, English, online tools...);

- team productions are necessarily global (global introduction, table of contents, bibliography, conclusion, …) but include contents relative to a specific team member depending on his role.

Project Management	**Communication - Intercultural**	**Business - Marketing**	**Industrial Design - Art**	**Engineering Design**
Project life-cycle, phases Project communication Requirements for Check Points Students' teamwork on communication planning	Presentation of the learning objectives, content in Moodle and main theories (to be applied in the teams' project plan). Requirements for checkpoints Discussion on the pre-tasks. Setting learning objectives. Team activities to improve the knowledge of the different persons of the team- Icebreaker Activities (next-coleague presentation, A Random word story per team)			Presentation of Part 1 (general outline of the design process) Presentation of Part 2 (specs) and group activity

Table 3.1: MUPIC matrix (kick-off week)

Team report					**Individual**
Project Management	**Communic. & Intercultural**	**Business & Marketing**	**Industrial Design & Art**	**Engineering Design**	**Communic. & Intercultural**
Project initiation: ▪ project Charter ▪ stakeholder analysis ▪ preliminary requirements (from all the stakeholders) ▪ preliminary project plan	Communication report with **team reflections** on communication and intercultural aspects in virtual teams: (as part of the project report!)	▪ Stakeholders identification ▪ Market research ▪ Setting economic targets ▪ Market analysis with a focus on competitive or related products	Design study ▪ competitive ▪ expected	▪ Elaboration of the problem ▪ State-of-the-art (partial) (SWOT of competitive products, analysis of patents, …) ▪ Potential innovation space ▪ Requirements specifications	**Individual diary reflection** on **a**)communication and intercultural aspects in virtual teams (follow instructions in Module 1): ▪ cultural identity ▪ media synchronicity **b**) learning

Table 3.2: MUPIC matrix (check point 1)

Team report					Individual
Project Management	**Communic. & Intercultural**	**Business & Marketing**	**Industrial Design & Art**	**Engineering Design**	**Communic. & Intercultural**
▪ Detailed plan ▪ Work Breakdown Structure ▪ Requirements documentation ▪ Project progress report	Communication report with **team reflections** on communication and intercultural aspects in virtual teams: (as part of the project report!)	▪ Adding product requirements based on the "market" analysis (Must have ▪ Should have – Could Have – Won't have) ▪ PESTEL analysis	▪ Concept Draft Design Sketch ▪ Consultation of expected design ▪ Rough concept of presentation of the project	▪ State-of-the-art (final) ▪ Conceptual Product Design (incl. conceptual alternatives, their SWOT evaluation and decision (prediction of properties and performance is an inherent introductory part of the SWOT evaluation and decision)	**Individual diary reflection** on **a**)communication and intercultural aspects in virtual teams. (follow instructions in Module 1): ▪ communicative styles ▪ trust & conflict management **b**) on learning (instructions in the diary)

Table 3.3: MUPIC matrix (check point 2)

Team report					Individual
Project Management	**Communic. & Intercultural**	**Business & Marketing**	**Industrial Design & Art**	**Engineering Design**	**Communic. & Intercultural**
▪ Project progress report ▪ Project change management documentation	Communication report with team reflections on communication and intercultural aspects in virtual teams: (as part of the project report!)	▪ Cost evaluation ▪ Quality prediction	Consensus concept with construction and economic optimisation for the preliminary layout	▪ Constructional Product Design "First iteration" = rough (initial) layout ▪ Innovation proposals based on the (suboptimal) conceptual alternative. ▪ SWOT evaluation of the 1st Draft proposal (update of the prediction of properties and performance)	Individual Diary reflection on a)communication and intercultural aspects in virtual teams (follow instructions in Module 1): ▪ netiquette and ethical aspects ▪ communication problems b) on learning (instructions in the diary)

Table 3.4: MUPIC matrix (check point 3)

Team report					Individual
Project Management	**Communic. & Intercultural**	**Business & Marketing**	**Industrial Design & Art**	**Engineering Design**	**Communic. & Intercultural**
Project management: -Deliverables according to the plan -Project closure report -Lessons learned documentation	Evaluation of reflections/learning Setting new individual learning objectives. Communication report (as part of the final project report) Communication (oral and written communication) of the results in the final presentation	Reflecting of benefits Marketing proposal, product cost prediction	Visualisation and final design base on the final design Final design study	"Second iteration" = definitive (dimensional) layout: global drawing of the system, with nomenclature (bill of materials) + additional drawings relative to the Detail Product Design (defining original parts you designed, assemblies, …) Completed design project documentation (technical report including SWOT evaluation of the alternatives, description of the proposed design, dimensioning of machine parts, description of ???	English Language test after the course

Table 3.5: MUPIC matrix (final report)

Besides, Table 3.6 illustrates how organization points and/or deliverables ensure the acquisition of the main targeted soft skills, i.e.

- blended international multidisciplinary activity;
- communication in English;
- collaborative work in multicultural and multidisciplinary virtual teams;
- professionalism and employability.

Organization/deliverable	Blended activity	English	Online collaborative work	Professionalism
Team composition	X	X		X
Common reports		X	X	X
Common presentation		X	X	X
Specific role and outputs	X	X		X
Regular feedbacks		X		X

Interaction with teammates, supervisors, experts, external partners		X		X
Outputs in terms of team work, multicultural aspects			X	X
Few « in person » meeting			X	X
Management plan			X	X
External partners		X		X

Table 3.6: Acquisition of competences

The construction of the final mark is another important concern. It is recommended that the mark includes personal productions and a cross evaluation (students evaluate their team mates). The 2 latter points are useful to detect free runners. To give an order of magnitude, the following formula was used during the MUPIC project

$$score=(A*0.20 + FR*0.35 + PP*0.15) + (ILPE* 0.20 + CE * 0.10)$$

- A: Assignments (check point deliverables produced by teams): 20%,
- FR: Final Report: 35%,
- PP: Project Presentation: 15%,
- ILPE: Individual Learning Process Evaluation: 20%,
- CE: Cross Evaluation among students: 10%.

The evaluation, especially assignments and final report involve several evaluators. Each partner should provide evaluators in several fields in order to construct a rich feedback. As evaluators may have different sensitivities and priorities, some uniformization must be introduced in the process. It is still more true when external partners are involved. A good practice consists in using rubrics as illustrated in Tables 3.7 and 3.8. Evaluations must be accompanied by comments so that students understand their mark and more importantly can improve their work. Another good practice consists in filtering the comments before their publication to students to avoid contradictory positions. This job can be ensured by coaches, especially if they are not involved in the evaluation. The consequence is that a few more days are necessary between the feedback of the evaluators and the feedback to students.

Inevitably all marks result from the combination of several partial marks (at least different evaluators and different domains). Weighted averaging is a usual practice but other methods can be adopted (median, weighted median/percentiles, olympic average).

WRITTEN COMMUNICATION RUBRIC

Express clearly through the written communication, in a foreign language, adapting to the characteristics of the situation and the audience to achieve their understanding and adhesion.

	EXCELLENT	GOOD	SUFFICIENT	INSUFFICIENT	WEIGHT	SCORE
	4	3	2	1	%	Between 1 and 4
INFORMATION SEARCH	There has been a very good search of information and the best sources have been chosen. Those sources consulted have been referenced correctly.	In general there has been an effort to search for information. Information have been selected correctly although sources were not referenced properly.	An effort is found in the search for information, although not always the information selected is the most appropriate. Sources were not referenced properly.	Little effort in the search of information; few or no sources have neither been consulted nor referenced.	10 %	
ELABORATION OF THE CONTENT	The content has been developed very well; it adapts to the demands raised by MUPIC Project and its approach is original and innovative.	The content has been developed quite well and adapts to the requirements settled by MUPIC Project.	The content adapts sufficiently to the demand raised by MUPIC Project, but does not provide too much added value.	The content is not adapted to the demand raised by MUPIC Project and has been little elaborated and argued. It contains "copy-paste of internet", not referenced.	35 %	
LEVEL OF CONCLUSIONS	The work ends with a perfectly argued final conclusion that shows the scope in the reflection of the students.	Some conclusions are drawn up with a brief reflection. The work has some added value.	The work is concluded with a brief conclusion but with little added value.	There are no conclusions or they are very poor and do not reflect a final reflection from the students.	35 %	
ORGANIZATION OF THE CONTENT	It shows a very clear and sequenced planning. The different aspects in the index are defined correctly.	The organization of the work is clear and its planning is easy to understand. There is no index or it was not prepared properly.	The work is sufficiently well organized, although the format can / must be improved.	The work is not well organized, the points to be discussed are not understood and it is difficult to understand its outline.	10 %	
FORMAL PRESENTATION	Well worked and visually attractive, original and innovative.	Careful and well worked.	Acceptable presentation but without any added value.	Neglected and unattractive presentation.	10 %	
					TOTAL	0
					Referenced to 10	**0**

Table 3.7: Written communication rubric

ORAL COMMUNICATION RUBRIC

Express clearly through the oral word, in a foreign language, adapting to the characteristics of the situation and the audience to achieve their understanding and adhesion.

	EXCELLENT	GOOD	SUFFICIENT	INSUFFICIENT	WEIGHT	SCORE
	4	3	2	1	%	Between 1 and 4
PREVIOUS PREPARATION	It shows that the presentation has been prepared carefully and in detail, showing all aspects of the work done and all resourses used during the project.	It shows that the presentation has been prepared quite well, although some kind of improvisation is shown.	The preparation of the content is quite evident but there were many improvisations during the presentation.	There is no prior preparation, and there are conceptual errors in the presentation.	15 %	
DEVELOPMENT OF THE CONTENT	The content has been very well developed, it adapts to the demands raised by MUPIC Project and its approach is original and innovative.	The content has been quite well developed and adapts to the requirements of MUPIC Project.	The content adapts sufficiently to the demand raised by MUPIC Project, but does not provide added value.	The content is not adapted to the demand raised by MUPIC Project and has been little elaborated, connected and argued.	30 %	
GRAPHIC ELEMENTS	The graphic elements of the presentation are totally appropriate and in line with the requirements of a professional work.	The graphic elements of the presentation are appropriate, but other elements could have been used to facilitate understanding.	Although the speech is well organized, by excess or default, the graphic complements of the exhibition are quite poor.	There are no graphic elements included in the presentation.	15 %	
ORAL LANGUAGE	Establishes a total communication with the audience, provokes interest and involvement with his speech.	The presentation gets the audience to listen but the presenter has some deficiencies in verbal fluency.	Although the presenters speech are more or less coherent, it do not manage to get the attention of a significant percentage of the audience.	The presentation is quite boring, does not attrach the audience and denotes many deficiencies.	20 %	
NON-VERBAL COMMUNICATION	The presentation is accompanied by the gestures, tones, uses of space, looks and speeches that are close to perfection.	In most cases, presenters manage to accompany their speeches with gestures, tones, looks and uses of space that are correct.	Acceptable presentation of non-verbal resources, but without any added value or pretty limited.	Null accompaniment of the non-verbal component to the oral discourse, causing monotony, poor commitment and disconection in the audience.	20 %	
					TOTAL	0
					Referenced to 10	**0**

Table 3.8: Oral communication rubric

Some good practices.

- The kick-off and final events are good candidates for in person meetings if it is possible. It is easier for students to collaborate if they met physically and they appreciate to see each other again at the end. Let us note that due to CoViD restrictions, teams were able to complete their project without any physical meeting during the MUPIC project.
- The first steps of the project are crucial to initiate team spirit. Icebreaker activities are necessary but not sufficient: it is important that students have to produce a common work, even though small-scale, during the kick-off week. As an example, during pilot 2 of MUPIC, they had to produce a specification sheet (of a simple object) and had a presentation of about 15 minutes at the end with a description of the members, the name chosen, and the adopted communication plan.
- The task must be defined in such a way that the workload is fairly distributed. Each student must be assigned a contribution to feel useful and if the workload is too large in a discipline, the composition of the team must be adjusted (there were more engineers in MUPIC as the companies were technical).
- It happens that students quit, for various reasons. Students must be conscious of that aspect and anticipate it. During MUPIC, students had to perform from the beginning a risk analysis among which the abandon of a member. In such a situation, flexibility may

be necessary from the students: e.g. an engineer took after project management when the leader left. In such a case, requirements must be lessened accordingly.

Support

The recommended forms of support have already been cited. Nowadays several items will be offered through internet usually in the form of a learning platform or course management system like Moodle. The latter can be easily configured so that students can access information about the project, teaching modules, can post and receive messages through discussion forums, can submit deliverables or can get self-evaluation through online tests. Once involved in the project, students must find easily the complete information about calendar, deliverables, requested outputs, evaluation, roles of experts and coaches,… Automatic reminders a few days before the deadlines can be useful.

All teams should have a coach well aware of his mission, designated from the beginning. Coaches are more facilitators than instructors and, in order to increase trust, are usually not involved in evaluation. They can however be consulted for comments or explanations.

Experts should be selected in each domain involved in the project, the list being permanently available including contact information. Several communication channels can be used: in person meeting (if the expert is in the same university as the student), e-mails, forums, so that communication rules must be clearly defined from the beginning.

Lastly, it turns out that present students, who are familiar with smartphones and social networks, do not encounter problems for using online tools in order to share documents, chat with team mates or organize meetings. However, all partners must ensure that students have a good internet connection and possibly access to professional online communication tools like Microsoft Teams or Zoom which generally prove more stable than free counterparts. Advices can be provided for the selection of the tools as well as advices or tutorials to use the tools at their full potential. In particular, advices concerning efficient tools for the construction of a common report will be welcome as this exercise is generally less natural.

Some good practices

- Project manager has little to no possibilities to react to lack of commitment from one group member. A mechanism may be proposed to help them in case of problem.
- Communication between people with different backgrounds proves difficult (more than different cultures). Specific meetings must be planned (engineering/marketing, engineering/design, design/marketing,…) to have an alignment of the objectives and to prevent developing several parallels projects rather than a common one.

iv. Quality

It is important to regularly analyse the feedback from students (through surveys, the coaches or meetings) in order to adapt the project implementation sufficiently early in case of issue. The feedback may concern the level of satisfaction, the acquisition of skills, the quality of organization, the bad and good points of the experience, the distribution of work, the fairness of evaluation, ...

The feedback is generally fed by questionnaires (filled in physically in case of in person events or through internet surveys) or interviews (alone or by teams). Typically, questions consist of a statement with which participants agree or disagree (Table 3.9).

Statement	--	-	+	++
The project met my expectations in terms of English language				
The work was fairly distributed among team members				

Table 3.9: Questionnaire (--=strongly disagree, -=disagree, +=agree, ++=strongly agree)

The feedback from partners is also important in terms of management, organization, facilities, … Out of conflicts or ad hominem issues, informal discussions can replace questionnaires. Quality can be a systematic point at the agenda of regular meetings.

4. The collaborative, multidisciplinary, international dimensions

Blended learning is a deliberate mix of face-to-face and distance-based on-line activities, with the goal of stimulating learning and overcoming organizational constraints especially when frequent physical meetings are not possible due to distance constraints.

According Boelens *et al.* (2022), there are four key challenges to designing blended learning:

1. flexibility (control over time, place, path, or pace of learning);
2. interaction, despite of the transactional distance linked to an enlarged psychological and communication space;
3. self-regulation of students' learning processes, requiring different skills: organization, discipline, time management, ability in using different communication channels;
4. affective learning climate: showing empathy, having a sense of humor, providing encouragements, directing attention to task-relevant aspects, and attending to students' individual differences.

5. Proposals to include 4.0 dimension

Skills related to 4.0 industrial models:
Organising data, sharing and editing project related information online
New opportunities for product features
Company business model canvas 4.0
Sensors and data use for performance indicator, detection, diagnosis, prognosis

6. Proposals to include sustainability dimensions (to be completed)

Skills related to sustainable development:
Integration of the lifecycle during the design process: circular design
Evaluation of sustainability indicators during the lifecycle: carbon footprint, …
Circular economy aspects: recycling, remanufacturing, reuse, …

7. Conclusions

The review article on Design Theory and Methodology [Tomiyama 2009] published more than 10 years ago already identified the need for further improvements: consideration of multiple stakeholders with different cultural and educational backgrounds, integration of advanced ICT technologies and advanced collaborations methods. New contributions have been published on design for sustainability practices ([Watkins 2021]). The Time2Go4.0 project will put these ideas in practice with their own students in collaborative projects. Other schools are welcome to join the community.

There is an obvious added value to perform design projects in a collaborative mode with different engineering schools: every institution develops different trainings in engineering with variable number and workloads for design projects or internships in industry. Some schools develop projects with detailed drawings as deliverables, other will favor more global systemic approaches. It is still interesting to discuss which profile a top engineer should have: a manager, a technologist, a scientist, an entrepreneur? There is no clear answer of course, but one skill must be developed: a top engineer must be able to communicate with other specialists and stakeholders and must be trained to contribute to complex international projects in hybrid modes.

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