

# Management of Interdisciplinary Project Approaches in Engineering Education: a Case Study

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## Abstract

This paper describes project management processes of coordination teams, in the implementation of interdisciplinary project approaches in Engineering Education. These interdisciplinary projects are based on the Project-Led Education (PLE) concept and are being implemented since 2004/2005 in the Industrial Management and Engineering (IME) master degree course (1<sup>st</sup> and 2<sup>nd</sup> cycle of Engineering Education) at University of Minho. Usually, these approaches involve a coordination team of 10 to 15 members with different roles: teachers, tutors and education researchers. This team is responsible for preparing the project for the semester and forming the students' teams. The coordination of these two types of teams is centred on a project manager that is responsible for, and supports, all the work developed during the semester, e.g., prepare the initial presentation of the project to the students, prepare the web site that supports the work, establish the communication between students and the rest of the team, prepare the students' guide, and so on. Managing these projects is an intense task that demands a lot of time and different competencies. In this work it is presented a project management framework based on project management knowledge areas, to aid coordination teams to achieve better results.

Keywords: project management; interdisciplinary project approaches; engineering education.

## 1 Introduction

Traditional teaching methods being adopted in higher education across European Universities are not contributing effectively to the real needs of today's world. The current challenges that the world is facing, concerning the new economic paradigms, centred on eco-sustainability along with global and unbalanced competitiveness, demand new answers from the universities. The professionals that universities must create should be prepared with the right set of hard and soft skills so they can rapidly contribute with new energy to the existing enterprises and other organizations.

The Bologna process, besides the objectives of making the European higher education more comparable and more compatible, includes also the objective of finding solutions to the reality described above. The Bologna process emphasizes the importance of student-centred approaches, promotes the implementation of more effective active learning practices and considers as a fundamental issue the reduction of the gap between learning outcomes and real world needs. This process also advocates that greater efforts should be made to create learning activities with "meaning" for students to provide additional motivation to the students as they are able to understand the reasons why they should learn the proposed course subjects.

One of the methodologies used to achieve the previously described objectives is based on interdisciplinary project approaches. A project can be looked as a field of application of more theoretical stuff, and can also act as a driver for better comprehension of theory. Interdisciplinary projects bring up the necessity to understand the interaction between different curricular units (CU) and develop project elements to address this issue. Powell & Weenk (2003) presented an interdisciplinary project approach, the Project-Led Education (PLE), which is based on a project supported by some of the curricular units of a semester (PSC - Project Support Courses), developed by teams of students. All the teams develop the same project theme in order to create similar evaluation conditions. Nevertheless, the proposed project is open enough to allow quite different solutions, allowing thus the development of student's initiative and their ability to take decisions with incomplete/redundant/fuzzy information. These teams should be large enough to impose difficulties both in the project and in the coordination team. These are conditions to improve the development of several additional transversal competencies such as: team work skills; leadership skills; project management skills; communication skills; and so forth.

These learning project approaches are different every year, and can be characterized by different ways of implementation during a pre-defined time period. Managing this process is equivalent to manage different operations every edition with scarce resources during a pre-defined time period. This “one of a kind” characteristic is the fundamental difference between project management and operations management, and reinforces the need to manage these processes as projects. In these projects, the following subset of PMI (2004) PMBOK Guide’s project management knowledge area processes get a higher attention from the coordination team: management of one team of staff and several teams of students; management of physical resources like class rooms and project rooms; management of communication between stakeholders; management of time; management of risks.

The main objective of this paper is to present a management framework, centred on time and team management, for project coordination teams, oriented to project led engineering education initiatives. These projects involve a coordination team and several students’ teams engaged in medium/large projects as close to reality as possible. To accomplish this, there is a sub-objective of characterization, in several project oriented learning initiatives, of the following project management knowledge areas: team management, time management and communication management.

Next section describes the project oriented learning initiatives that will be used as case studies. A characterization of processes from three different project management knowledge areas is presented in the following sections. In this learning project approaches the areas of human resources (team development), time and communication management were considered the most important because they get most of the attention of the project management team.

## 2 Project Oriented Learning Initiatives

This work is based on the project oriented learning editions that have been undertaken during the last four years with students mainly from the Integrated Master Degree on Industrial Management and Engineering (IME). Three of those PLE editions were implemented in as many different semesters of the IME course, and the corresponding projects will be identified as follows: IME11 (1st year, 1st semester); IME41 (4th year, 1st semester); IME42 (4th year, 2nd semester). The IME41 project involves all the six curricular units (CU) of that semester while both IME11 and IME42 include four out of five CUs of the corresponding semesters. The total work load of the project should be based on the total ECTS (European Credits Transfer System) allocated to the PSCs (Project Support Courses). This is not an easy task because every PSC has some competencies developed outside the project theme, which are not considered for the project evaluation process. It can be said that total load ranges from 12 to 25 ECTS in the first year project and from 15 to 30 ECTS in the fourth year projects.

Another initiative in project based learning at University of Minho is designated as Innovation and Entrepreneurship Integrated Project (IEIP) and it is a multidisciplinary optional curricular project with teams of students from four different technical backgrounds, all of them from the fourth year of an engineering integrated master course. These four different Engineering Integrated Master courses are: the already referred IEM; Polymer Engineering (PE); Industrial Electronic and Computers Engineering (IECE); and Mechanical Engineering (ME). Two editions of this innovative experience were already completed in 2007/08 and 2008/09, involving four teams of six and eight students respectively (two students from each master course). They have worked during the entire semester, on proposals to improve industrial products and production systems. The problems to be solved by those multidisciplinary groups of students were presented by local companies willing to get real improvements in their products and processes. This project had different workloads allocated to each master course, ranging from 7.5 to 12 ECTS.

## 3 Project Management Team Characterization

All project based learning initiatives presented above (IEM and IEIP) undertaken at the Engineering School of University of Minho require coordination by academic staff. The characterization of the staff project teams is presented in Table 1. These teams are more or less constituted by the same people, changing one or two persons from one year to another, e.g., in the coordination team of IEM11, almost all members have been the same, except the CC teacher. This brings the additional difficulty of explain the PLE project and accept the decision of participate/not participate of the responsible teacher of this CU.

Typically the coordination teams for those initiatives include lecturers, tutors as well as researchers from the educational field. Sometimes the same staff member accumulates both the role of PSC lecturer and of tutor of a

given team of students. According to Alves *et al.* (2007) and Fernandes *et al.* (2007) tutors play an important role in this process since they get very closely involved with different tasks and aspects of the students' teams.

Table 1: Coordination team characterization

	IEM11	IEM41	IEM42	IEIP
Elements of the Coordination Team	11	10	11	15
Teachers	6 (teachers of several PSCs from different departments and from different schools)	8 (teachers of several PSCs from different courses. IEM course director is one of them)	6 (teachers of the five PSCs)	11 (teachers of several PSCs from different departments; one company representative)
Tutors	6 (3 are also teachers of PSCs)	4 (3 are also teachers of PSCs)	5 (1 is also teacher of 2 PSCs)	4 (1 from each department)
Education Researchers	2	2	2	2

These coordination teams are characterised by a matrix organisation, where each element is associated with different knowledge areas and has a high level of autonomy. According to Lima *et al.* (2007) the members of the coordination team also have to deal with project management and personal interrelationships issues. Project management has to do, mainly, with the schedule coordination, deadline achievement and project's tasks planning and organization. In the personal interrelationship area, the main challenge is the management of conflicting situations due to: divergences on opinions, ideas and individual objectives; attitudes and position confrontation; lack of communication inside the team. To deal with these difficulties, which occur during the entire project, adequate strategies are demanded. Understanding and overcoming these difficulties are two important components both of the learning and the coordination process.

Each coordination team needs a project manager which is the semester coordinator nominated by the Course Director. However, there is no hierarchy in the coordination team - the project manager should negotiate all important decisions. Project manager, as described in PMI (2004), acts like a coordinator in a loose matrix organisation type. The results of the project cannot be totally assigned to the project manager; nevertheless, he has the responsibility to build a coherent pedagogical model and motivate colleagues to embrace it. He must be prepared to deal with conflicts, absences to scheduled meetings, delays in tasks' delivering and to deal with teachers that, by nature, are more sensitive to criticism from colleagues. Some resources, like project rooms, are dedicated to the project but must be allocated to all the projects of the semester and that must be negotiated with both the IEM course director and the director of the Production and Systems Department director.

The project manager also has to manage the students' teams and solve all problems related with them, like schedule training sessions provided by the Courses Council and assure that the students go to these sessions in the IEM11 or assure that, in the final of the semester, the project rooms stay clean and the laptops are returned to the department. During the semester there are several activities and milestones to be delivered by the students where the presence of project manager is fundamental - Alves *et al.* (2009); Carvalho & Lima (2006). The compilation of final grades for the project is a task of project manager and this compilation involves a grading model which is somehow complex - Moreira *et al.* (2009); Fernandes *et al.* (2009).

## 4 Project Time Management

Before the beginning of each PLE semester, several informal brainstorming sessions take place in order to prepare the incoming project – the main purpose is the definition of the project's theme. Neither the number nor the duration of these sessions is predefined, but usually they start in the months before the semester begin. After this, and to manage the entire semester, the coordination team builds up a schedule for a horizon of 18 weeks. This schedule includes not only the specific activities of the coordination team, but also the activities involving both staff and students. In the beginning of the semester, during one to two weeks, students must execute a mini-project with the objective to simulate the whole semester process. Table 2 presents some activities developed during the execution of the project, along with the correspondent number of occurrences (semester basis), for each of the four project oriented learning initiatives.

Some activities occur every week (e.g. PSCs classes and tutorial meetings) while others are distributed along the semester (e.g. staff meetings and teachers' feedback). Table 2 shows that the number of occurrences of some activities varies significantly depending on the PLE project and, naturally, this implies some differences in the effort associated to project time management. However the time spent on each type of activity is not so different from project to project, except, eventually, for the IEIP case, due to its nature (section 2).

Table 2: Activities involved in the project oriented learning initiatives

	IEM11	IEM41	IEM42	IEIP
Staff Meetings	10	4	4	4
Milestones (for students)	10	6	6	6
Teachers Feedback Events	7	3	4	3
Extended tutorial meetings	2	1	4	3

The higher number of staff meetings, milestones and feedback events associated to IEM11 demands an accurate monitoring and control of the time spent. The duration of each staff meeting should be, approximately, one hour. The agenda is defined in the previous meeting and includes the expected duration of each topic. During the meeting a time controller (in every meeting this role is attributed to a different member of the coordination team) monitors the time spent on each topic and immediately announces any delay. Thus the president of the meeting can take the adequate action (conclude the topic, if possible, or postpone it to the next meeting). Despite this time management effort, sometimes the one hour duration is exceeded (e.g. in the IEIP staff meetings, probably due to the dimension of the coordination team – 15 members).

The time management associated to students' milestones is simple but, mainly due to the number of occurrences along the semester, it is somehow laborious - Alves *et al.* (2009). One of the staff members should verify if all the students' teams have met the correspondent deadlines and if they have delivered the expected elements (reports, presentations, prototypes, etc.).

The feedback activities referred in Table 2 are of two types: presentations' feedback and reports' feedback. During the semester, and depending on the PLE project, there is a minimum of three multimedia presentations (initial, intermediate and final) and two written reports (final preliminary and final). Typically the presentations' feedback is not time-consuming and it is usually provided in oral form to the students. On the contrary, the reports' feedback demands a lot of time, except for the final report (this report is assessed but no written feedback is provided). Each PSC teacher should perform a detailed analysis of each team's report and write down a full set of relevant comments/corrections/suggestions. Each teacher has its own time management approach to deal with these activities but, occasionally, some teachers do not meet the deadline. However, the semester coordinator, which is also the project manager, should continuously monitor the execution status of all the activities, in order to avoid deadlines' overcoming (both by teachers and students).

In terms of time management, the extended tutorial meetings are similar to the staff meetings. The time controller and the president ensure that the meeting with each team of students does not exceed 20 minutes, approximately.

An estimative of the time spent on project supporting activities, by project manager, teachers and tutors, is presented in Table 3, including some of the activities listed on Table 2.

Table 3: Time spent on project supporting activities

	IEM11	IEM41	IEM42	IEIP
Project Manager	One hour per week	One hour per week	One hour per week	One hour per week
Teachers' time for project support	Approximately 1,2 hours per week per PSC	Approximately eight hours per week	Approximately eight hours per week	Approximately eight hours per week
Tutors' time for project support	One hour per week per team.	One hour per week per team.	One hour per week per team.	One hour per week per team.

## 5 Project Communication and Information Management

The communication and information management in this type of projects includes mainly the staff team internal communication, the communication between the staff team and student teams, the communication inter and intra-student teams, the communication between student teams and the company representatives when applied,

and the communication to the outside community. There is a concern not only with the exchange and understanding of information between all the elements, but also with the preservation of the necessary privileges and restrictions to data availability.

The projects presented in this paper typically involve 7 to 9 lecturers (some of them acting only as tutors), 3 to 4 researchers and 30 to 50 students. The communication network can be quite complex not only due to the number of people involved but also because of the complexity of roles and complexity of privileges/restrictions to data availability. Managing all the communication, documentation and information in this type of projects can therefore be quite demanding. Different levels of confidentiality must be preserved and managed in the network of teams and from the outside world. Examples of restriction are:

- In some cases the company/product information must be preserved from the outside world while being available to all students and staff members. On the other hand the company may not be interested in part of the important information shared among staff members.
- Each students' team may want to preserve to themselves some data that may be or may not be shared with their tutor or with some other staff members.
- Students' teams must keep updated information and data available to every member and to their tutor, keeping the track of document changes, keeping accurate plans, etc. On the other hand most of such data must not be available to other student teams.
- The staff team must feed all students' teams with some critical updated information: re-planning information, changes in resource availability, feedback information, assessment information, etc.
- Researchers require information that may or may not be available to students, tutor or other lecturers.

A list of the main types of tools and types of documents used for communication and information sharing is presented on table 4, for the Project Led Education projects reported on this paper.

Table 4: Main tools and types of documents used for communication and sharing of information.

	<b>IEM11</b>	<b>IEM41</b>	<b>IEM42</b>	<b>IEIP</b>
Documents	Project Guide Tutor guide Instructions for Reports Templates for Evaluation Bibliographic referencing rules Templates for the peer evaluation	Project Guide Instructions for Reports Companies documentation sent directly for related team	Project guide Instructions for reports List of topics to be deal with	Project Guide Instruction for Reports Company documentation Rules for company access
Repositories	Moodle forum accessible by the students team and teachers	Moodle forum accessible by the students team and teachers Students used "Microsoft Groove" and "Yahoo Groups"	Moodle forum accessible by the students and teachers	Moodle forum accessible by the students team and teachers
Email	Based on direct email; using the moodle participants list	Based on direct email; using the moodle participants list	Based on direct email; using the moodle participants list	Based on direct email; using the moodle participants list
Elearning	Moodle environment configured for the project Different teachers use different platforms to communicate with students: Moodle and Blackboard	Moodle environment configured for the project Different teachers use different platforms to communicate with students: Moodle and Blackboard	Moodle environment configured for the project Different teachers use different platforms to communicate with students: Moodle and Blackboard	Moodle environment configured for the project Different teachers use different platforms to communicate with students: Moodle and Blackboard
Informal	Direct contact is facilitated by proximity	Direct contact is facilitated by proximity	Direct contact is facilitated by proximity	Direct contact is facilitated by proximity

In terms of information management it may be said that special attention must be paid to the communication channels and what information should be exchanged with students' teams. Students' teams tend to be very demanding - they want to get information as accurate as possible at the precise moment when they need it. This may not be easy especially when companies are involved. Special attention must also be given to the internal organization of students' teams since they must learn how to plan and manage their formal meetings as well as keeping accurate records of team decisions and task assignments. In order to help them in managing their projects students must deliver results on several milestones along the semester, which keep teams alert without losing the track of the project.

## 6 Project Management Framework

Characterization of processes from three different project management knowledge areas was presented in the previous sections. In these learning project approaches the areas of human resources, time and communication management were specially analysed. Specifically on the time management knowledge area, and based on the analysis of the referred data, it was possible to foresee the project life cycle with five main phases illustrated in Figure 1: Preparation; Set-up; Start-up; Execution; End



Figure 1: Project Life Cycle Framework – Project Main Phases

Preparation phase starts 0.5 to 3 months before classes begin. During this phase, based on informal communication, a few team members start to contribute for the definition of fundamental aspects of the project: project theme; human resources; project support courses. This is the phase with lower workload demand for team members.

For the project specification it must be defined a project theme that is challenging and actual for both the students and the staff for increasing motivation. So in this context, some of the team members propose ideas that will be considered during setup phase in formal meetings of the coordination team. In the cases previously described a project can be purely academic (IME11 and IME42) or can have interaction with the industry (IME41 and IEIP). In the first case the limit conditions are imposed by course contents of the semester. In the other cases there is an additional constraint related with industry partners that must be found and also that must agree with objectives and main contents applied to the project.

Human resources and project support courses are closely related because teachers of courses associated with the project will be part of the team. Additionally there will be team tutors (also teachers) and, usually, researchers also. It is desirable that staff team members have prior knowledge and experience in the methodology. Nevertheless, in all editions there are teachers that participate for the first time. There is a key role decided during this phase which is the team coordinator that will act as a project manager. This should be a teacher with good organization skills and with in-depth knowledge about the methodology. The coordinator should maintain a high motivation and the project under control, both from the staff and students perspectives.

Setup phase starts 1 week to 1 month before the beginning of the semester and has the following main objectives: project theme definition and specification; milestones definition and planning; project and PSC assessment process definition; project process evaluation definition; project guide elaboration. During this phase the coordination team builds up a coherent plan for the entire semester that is materialised in the project guide. This guide works as a project charter for the project, describing the main objectives, the scope, milestones and evaluation process.

Start-up has the duration of 1 to 2 weeks, beginning at the first day of classes with a project presentation session. Depending on the project, students' teams will be created before this session (IEIP), at the end of this session (IEM11), or during the following few days (IEM41; IEM42). This phase can comprise students' training, mainly on first year edition. Start up phase is based on the idea of one week simulation of all semester process and also to get teams working on the project right from the first day of classes. At the end of this phase, students' teams make a presentation of their own project objectives and organization model that will act as a guide for project work.

Execution phase has the duration of 16 weeks with classes, tutorial meetings, deliveries, presentations and feedback sessions. Each PSC has classes for both theory and project support during the entire semester that can be mixed each week. The tutors are expected to have one hour meeting per week to support students' teams on aspects of transversal competencies development and project management processes. The coordination team should also prepare and control project milestones, and in some occasions prepare formal feedback to deliver to the students. During this phase students assessment his fundamentally formative and the summative aspects corresponds to approximately 20% of final grade.

The End phase has duration of 1 to 3 weeks. At the beginning of this phase, teams have to deliver final reports. In one case (IEM11), this final report is followed by a written test. Prototypes can be delivered jointly with the reports or with the presentation of project. In all cases the project must be presented and discussed with all coordination team and only after this event students will receive their final grade.



There is not an intention to create a detailed work breakdown structure (WBS) for this type of projects in this framework but it is possible to describe some of the main types of activities that should be included. The main activities envisaged on the analysis developed in this work are: theme definition; project support courses definition; human resources management; evaluation process management; assessment process management; milestones management; internal resources management (non HR); external resources management. It is clear from the above text that some of these activities have sub-activities spread along project phases. As an example, theme definition has one sub-activity related with generation of ideas during the preparation phase and others for theme selection, definition and specification during setup phase.

From the point of view of knowledge area of human resources management these project approaches are based on teams of 10 to 15 members that include teachers, tutors and educational field researchers. These teams are characterised by a loose matrix organisation. In this type of organisation the project manager act more a project coordinator that have to negotiate all important decisions. In order to build real team's spirit, team members should identify themselves with the organisation. In this context members should be part of the decisions and should contribute for project management processes. So, these teams must share activities and roles, both pleasant and unpleasant. Presence in most of the project events is a step for accomplishing the objective of team's spirit building. As an example, members should actively participate in staff meetings and act like chair, note keeper and time controller in accordance with a rotational schedule. After contributing for project guide construction, several members should aid and participate on project presentation execution. During execution phase team members should participate in assessment and feedback activities. Acting simultaneously with different roles and with commitment to the team objectives is the foundation stone for team's spirit development and high performance achievement, in these interdisciplinary project approaches. Figure 2 represents the main roles that staff members must interpret in different situations during the project. Most of these roles were explicitly referred previously in this work, but roles referred as "outside" were not.

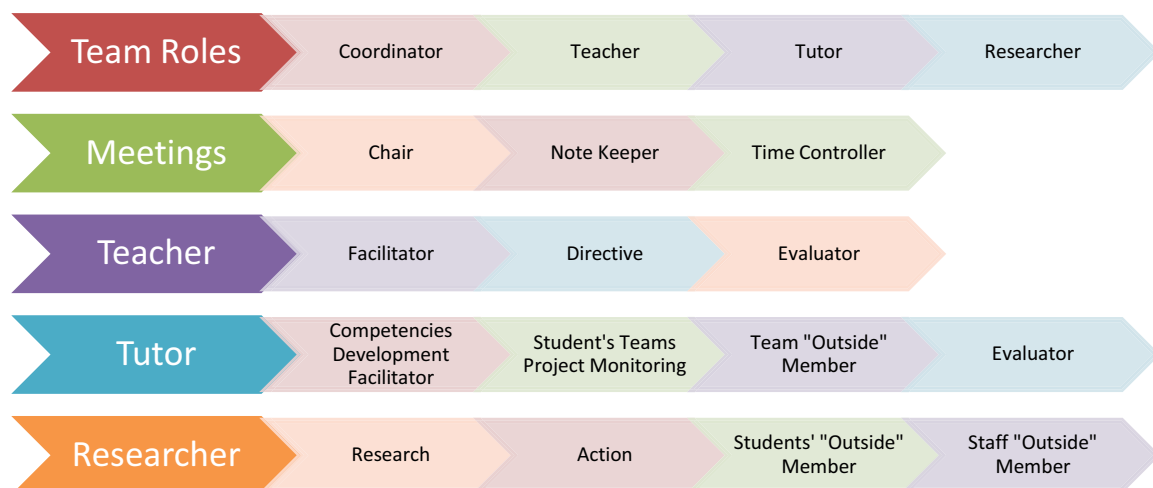


Figure 2: Roles of different staff team's members

As an example, tutor is an "outside" member of students' teams because he (she) should simultaneously be close enough to understand teams' main conflicts and problems and far enough to restrain any temptation to execute activities for the team. Researchers have similar roles because they must be close to students to understand fundamental learning issues. Furthermore they execute some activities of the staff team but they are not involved in teaching activities and don't have responsibility on students' assessment.

## 7 Conclusion

The coordination of projects like the ones here presented is not very different of other projects with different teams to manage, limited resources and time. Project management of these types of projects faces challenges that overcome the traditional teacher role. Thus, teachers that want to embrace this type of project have to be prepared for this.

Characterization of team management and communication management in these project oriented learning initiatives allowed the identification of different roles for staff stakeholders. Interdisciplinary projects for a whole semester need a coordination based on a real team spirit. Clarification of these roles and sharing them between

coordination team's members help feeling the project from different angles, and to share responsibilities and decisions. Sharing responsibilities and decisions help to interact with commitment and to achieve higher interdisciplinarity. Building a characterization of time management activities for project oriented learning initiatives can help coordination teams to identify and develop time management processes. These processes should help staff to keep the project under control. Among these there are several main processes that can be classified in learning facilitator activities, organization activities and communication activities.

PMI (2004) presented several project management knowledge area processes that can help project managers to select, develop and execute adequate processes for each project. Nevertheless, the project lifecycle for a specific domain is not known a priori and can be different for each team or project manager. Based on four cases of interdisciplinary project oriented learning initiatives it was built a project lifecycle for this kind of projects. This project lifecycle includes five phases with different durations and capacity demand that can be adapted for each project instance: preparation; setup; start-up; execution; end.

This framework allowed clarifying and formalising project management life cycle processes of these similar learning project approaches. This can be used for re-evaluation and reorganization purposes of these approaches. Furthermore, it can be used for new project approaches as a possible way to manage processes. It is now clarified where human resources are used during project management processes, what are the main types of activities developed and also what are the interactions between successive phases of the project life cycle.

Valuable inputs for management of this type of learning projects could be done in several domains: team building; information management; communication management; risk management; etc. It is now commonly accepted that people can make management decisions to be highly effective or to fail. So, understanding teams that perform well and trying to build organization models based on those cases is one way to develop this area. Furthermore, investing time on augmenting the effectiveness of management teams could help to get better learning results with less staff effort. This could be done based on improved processes of information and communication management and also on reducing risks.

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