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Project Based Learning in an International Context in Sustainability and the Global Economy. T.I.M.E. European Summer School: A Truly European Learning Experience*

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In this paper an innovative experience developed by seven Universities (six European and one non-European) to teach a two weeks summer course in a non-conventional, remotely way is presented. The course is developed using a Project Based teaching-learning methodology and it is also designed to have a deeper knowledge of the relationship between sustainable development and the economic and financial conditions. The experience is innovative because the technology used, allowed students to share knowledge and participate from countries all over the world. Competences of students in this context are measured and strengthened. The most interesting issues, challenges and difficulties are presented here. Conclusions help professors to propose actions to improve the methodology in order to strengthen students' competences.

Keywords: project based learning; sustainability; global economy; remote learning experience

1. Introduction

This paper presents an innovative international learning experience that has been developed by six European universities: Universidad Politécnica de Madrid (UPM), KTH Royal Institute of Technology (KTH), Centrale Supélec (SUPELEC), Università degli Studi di Trento (UniTn), Budapest University of Technology and Economics (BME) and Istambul Technical University (ITU) and one non-European, the Open University of Sri Lanka (OUSL), to teach a common course in an unconventional, remote way, to geographically separated groups of students.

Nowadays we are experiencing a global crisis affecting the international context. An important concern regarding this situation is the relationship between sustainable development and the economic and financial conditions. The objective of this two week summer programme is to give the students a deeper knowledge of the relationship between both matters, on a global scale encouraging them to propose creative solutions for real problems in a global context. This course will allow students to have a deeper knowledge of the current situation on this matter and will sensitize them to the actual context positioning themselves as professionals.

TESS (T.I.M.E. European Summer School) course first ran from 2007 to 2010, the course dealt with sustainability, social models, religion and public affairs. In 2011, the content of the course was changed to focus on the relationship between sustainable development and the global economy [1]. In 2014, the partners implemented a new and unique pedagogical approach for the benefits of the students taking into account, lessons learned from previous experiences. It aims to be a challenge-driven education to propose solutions to real problems in a global context using Project Based Learning (PBL) methodology working seriously on the strengthening of student's transversal competences and measuring them.

2. State of the art

Project Based Learning (PBL) is a model in which learning opportunities are organized around projects [2]. If we consider the definitions found in PBL papers, projects are complex tasks that are based on challenging questions or problems that involve students in design, problem-solving, decision making, or investigative activities [3]. They give students an opportunity to work relatively autonomously over extended periods of time and culminate in realistic products or presentations [4–6].

Implementing PBL methodology knowledge is acquired through more active student participation by involving the student in tasks that come close to actual vocational development mainly from the point of view of the work environment.

Numerous studies around the world have proposed project-based learning [7, 8] as the most suitable means of achieving effective engineering competence-based education [9, 10] that integrates knowledge, skills and values.

There are five criteria that define what a project should have in order to be considered an instance of PBL [11]: centrality, a driving question, constructive

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investigation, autonomy and realism. These characteristics can involve the topic, the tasks, the roles that students play, the context within which the work of the project is carried out, the collaborators who work with students on the project, the products that are produced, the audience for the project's products, or the criteria by which the products or performances are judges. Reference [12] was the first to make a distinction between academic challenges, situation challenges and real-life challenges. PBL incorporates real-life challenges where the focus is on authentic (not simulated) problems or questions and where there is a possibility that solutions will be implemented.

In PBL, the project is the central teaching-learning strategy. Students encounter and learn the central concepts of discipline by means of the project. There is a longstanding tradition in schools of "doing projects", incorporating "hands-on" activities, developing interdisciplinary themes, conducting field trips, and implementing laboratory investigations [13]. It can also be viewed as an activity in which students foster understanding of a topic or issue through involvement in solving a real-life problem.

Therefore, PBL experiences are an excellent teaching-learning tool, especially in Engineering, for guiding students towards their future working life in industry, which will not only involve solving technical or financial problems on a daily basis, but also human problems [14]. This teaching-learning methodology has attracted particular interest in engineering also because of its potential to increase student engagement and improve skill development [15].

The inclusion of real-world problems in engineering education reinforces concepts and improves learning in ways not available with traditional lecture methods or predefined case problems [16]. Students develop problem solving skills, project management skills, communication and teamwork skills and a sense of professionalism from such experiences. It involves the assumptions of cognitive and social processes of learning and values interactions in problem-centred environments [17].

PBL presents new trends in the teaching of technical disciplines, assigning projects to groups of students with the goal of improving the learning of content [18–20]. Nevertheless, PBL encompasses a diversity of approaches, and no unique model or consistent paradigm has been adopted.

PBL has been applied in different contexts and in many universities with success [e.g. 21–24]. The experience presented here is applied to introduce the concept of economic, environmental, societal sustainability in international context. The next generation of engineers will need to be trained in the context of sustainability with an international perspective if they are to participate in solving problems of sustainability at local and global levels [25].

There is the recognition that engineering education does not do a good job of integrating technological development with development that is compatible with society and the environment [26]. The experience presented here applies PBL methodology remotely and in an international environment making it a real challenge for participants (professors and students).

3. TESS experience

3.1 Methodology used for the experience

The pedagogical approach toward the students' "remote presence" involves the different sites taking turns to have seminars each morning from Tuesday to Thursday during the first course week and from Monday to Wednesday during the second course week. The seminars are sent by synchronous Internet video links to the other sites. The web-based software Adobe Connect is used for sharing presentations and audio. Axis cameras are used for sharing live streaming between the class rooms. The teachers have a 30–45 minute seminar per day. The topics of the seminars for the courses in 2014 are shown in Table 1. The first day of the first week was used to introduce partners and students and to present the projects to be worked on at the different campuses. At the end of the day students should have the project charter with clear objectives, deliverables to performance during the course and responsibilities in the team.

TESS course had never been run using the PBL

Table 1. The topics of the seminars held in TESS 2014

Day of the course	Topics of the seminars
Tuesday, 1st week	European issues on sustainability & economics
Wednesday, 1st week	Superconductor technology for future power system
Thursday, 1st week	Corporate Social Responsibility
Monday, 2nd week	Polygeneration using renewable sources: biomass district heating systems
Tuesday, 2nd week	Clean Tech—Using Technology to Change the World
Wednesday, 2nd week	Sustainable transport systems in a global context

Table 2. Students' projects and number of students at different campuses in TESS 2014

Campus	Project	Number of students
UPM	Stand-alone energy system for clinic power supply	13
KTH	Stand-alone energy system for clinic power supply Make a middle-sized city sustainable! (students could choose one of them)	11
SUPELEC	Make a middle-sized city sustainable!	12
UniTn	District heating for rural areas	9
BME	Sustainability-based economic revitalization of an underdeveloped rural community	8
ITU	Make a middle-sized city sustainable!	12
OUSL	Stand-alone energy system for clinic power supply	21
TOTAL		86

methodology before 2014. With this methodology, students are involved in solving a real-life problem linked with the topic of the course (Table 2). The teachers (one teacher per day in one of the campuses) are encouraged to get students to participate. They moderate the discussion between campuses pushing students to share their knowledge. The students are organized in international teams at different campuses working on real projects. The projects at all campuses are worked on taking special care of the three dimensions of sustainability: social, environmental and economic.

86 students took part in the experience in 2014, coming from 14 different Universities in nine different countries. All the students had to fulfil the admission criteria for the course, having obtained at least 150 ECTS credits in engineering, natural science, architecture, economics or business administration and statement/proof of English proficiency, e.g. TOEFL, IELTS, Cambridge/Oxford certificates or a grade in English from Upper Secondary (High) School and/or from University.

The course offers five academic credits in the "European Credit Transfer System" (ECTS[1]) based on a full workload during the two weeks and the subsequent homework, which the students must complete.

Students worked in small teams (between 5 and 7 students if possible considering the number of students in the campus). The big number of different nationalities involved in the course made teams especially interesting from a cultural and international point of view. The mix of topics in previous studies also led to an extra challenge in the project work in the groups, due to the fact that they had been taught different methodologies in their previous studies. This was shown e.g. at KTH, where a student in Biology had to cooperate with students with an engineering background. The relationship between students and teachers, from different partners and countries, encouraged critical discussion of the results by strengthening the ability for analysis and critical thinking.

An important and interesting part of this study is that, all the students had to do at least one individual presentation during the course. This allowed teachers to evaluate communication skills of all the students. During teachers seminars, technical support and campus coordinators evaluate the ability to work in an audiovisual remote working environment both for teachers and students.

Taking into account all of the aspects that characterize the experience, careful selection of the software-based support system is fundamental for its success, as well as for monitoring and evaluating the impact of Web 2.0 collaborative software tools on the acquisition of competences. In this way, the communication competence is reinforced through both traditional and new interaction channels, on an individual and group basis.

At the end of the course all the projects were presented in front of a jury, who were teachers from all the partners. They were evaluated considering the technical quality of the deliverables: (40%); the public presentation at the end of the course (15 minutes per group) (30%); team working performance, estimated considering evaluation between students (10%); creativity and innovation in the proposal (15%); uses of blended learning platform (5%).

In the three first batches, the program was completely free of charge and most of the students were offered scholarships that covered their travel, accommodation and living expenses (Erasmus funding). Furthermore, there was no academic ranking of the students who applied, as long as they were registered as students at a T.I.M.E. partner university. For the 4th batch, a small fee, as well as a ranking system of the students, was

[1] This System is standard for use in comparing the study attainment and performance of students of higher education across the European Union and other collaborating European countries. One academic year corresponds to 60 ECTS-credits, which are equivalent to 1500–1800 hours of study in all countries, irrespective of standard or qualification type. The system is used to facilitate transfer and progression throughout the Union.

Table 3. Measurement scheme of obtained competences in the course

Competence	When to measure	How to measure	Who	
An ability to function on multidisciplinary and international teams		First day Last day	Rubric	Technical support and campus coordinator
An understanding of professional and ethical responsibility		One questionnaire at the end	Questionnaire	Technical support
An ability to communicate effectively		During intermediate and final presentations	Rubric	Technical support, campus coordinator and jury
The possibility to function in a multi-cultural audiovisual remote working environment	Students	During intermediate and final presentations	Rubric	Technical support campus coordinator
	Teachers	During the seminar of each teacher	Rubric	Technical support and campus coordinator
The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context		In the written document: alternative analysis must be included	Documentation analysis	Campus coordinator and jury
A recognition of the need for, and an ability to engage in life-long learning		One questionnaire at the end	Questionnaire	Technical support
A knowledge of contemporary issues		One questionnaire first week	Questionnaire	Technical support

Table 4. Communication Competence Rubric

Communication Competence Factors (CCF)	Achievement level			
	Unsatisfactory (1)	**Need improving (2)**	**Satisfactory (3)**	**Excellent (4)**
The student clearly organizes the content of the presentation (CCF1).	The presentation is disorganized and lacks logic structure.	The presentation is structured in a confusing way. The organization by sections, titles, points, etc. is not clear.	The presentation is in general clear, although some points are not well structured.	The structure of the presentation is clear, coherent and logic.
The student uses the adequate oral style to ease the instructors' understanding (CCF2).	The vocabulary used and overall level of the communication is not adapted at all to the audience.	In many aspects, the presentation is neither well structured nor oriented to the audience.	The style is adequate for the audience, although some ideas are expressed in a simple or complicated manner.	The presentation is perfectly done according to the audience, including the style and vocabulary used.
The student appropriately uses the corporal communication language (CCF3).	Presentation is done under nervous status or supported by notes. Oral techniques are not used.	Presentation is not well supported by communication techniques.	Communication techniques are generally well used, although sometimes the volume and the oral expression are not correct.	Message is reinforced, getting the audience attention and using adequately the communication techniques.
The student uses graphics and other technical resources to effectively communicate the information (CCF4).	Neither graphic nor additional resources are used. Video sound and/ or image are not clear.	Graphic and/or other resources are poorly used or inadequately applied.	Graphics and/or other resources are commonly used, but are not always adequate for the content of the presentation.	Graphics and/or other resources are perfectly used and in a professional manner.
The student selects the appropriate set up for the presentation (CCF5).	The set up doesn't help in any way the explanation of the presentation.	The set up selected made it difficult sometimes for the instructors to understand well.	The set up selected could be better by using lighting, colour and general atmosphere.	The set up selected is ideal for the video presentation.
The student has fluid communication with teacher using the technology available (CCF6).	There is no communication between teacher and student at all.	There is communication between the student and the teacher but it is not fluid and they (student and teacher) have difficulties.	There is fluid communication between the student and the teacher but they (student and teacher) have technical difficulties to communicate properly.	Communication between student and teacher is fluid. Technology available makes it easy.

Table 5. Possibility to function in a multi-cultural audiovisual remote working environment rubric

Audiovisual remote working environment competence factor (ARWECF)	Achievement level			
	Unsatisfactory (1)	Need improving (2)	Satisfactory (3)	Excellent (4)
Students				
The student participates actively during the class even if the professor is teaching in another campus (ARWECFS1).	The student does not participate at all during the class or only those students that are in the same campus where the teacher is actually present.	The students participate, but very few and only when they are required to do so.	During the class the students participate regardless of where they are located. The participation is not as satisfactory as if it were a "regular course".	The students participate actively during the class sharing reflections and questions.
The students really interact with each other "over the remote boundaries" (ARWECFS2).	The student does not know how to use the technology to interact with other students on other campuses.	The interaction between students is scarce and not always satisfactory.	The students work together even if they are allocated in different campuses, but not with students at all campuses.	The students clearly work together with others students located at any of the campuses.
Teachers				
The teacher uses the audiovisual remote working in an interactive way to make students participate at different campuses (ARWECFT1).	The teacher does not use audiovisual remote working in an interactive way to get students to participate during his/her class.	The teacher uses audiovisual remote working in an interactive way to get students involved but only in the campus where the class is thought.	The teacher uses audiovisual remote working in an interactive way to get students involved but not at all campuses.	The teacher uses audiovisual remote working in an interactive way and gets students involved at all campuses.
The technology is used properly to facilitate remote learning: the sound has high quality. (One rubric per campus) (ARWECFT2).	The sound during the course does not have good quality and it is difficult to understand what the teacher or other students are saying.	The sound during the course is not good enough to understand interventions of all participants.	The sound during the course is good enough to understand interventions of all participants. It could be better.	The sound during the course has a high quality making it easy to understand interventions of all participants.
The technology is used properly to facilitate remote learning: the image of teacher or students at other campuses has high quality. (One rubric per campus) (ARWECFT3).	The image of teacher or students at other campuses during the course does not have good quality and makes it difficult to go on with the course content.	The image of teacher or students at other campuses during the course is not good enough to go on with the course content and with interventions of all participants.	The image of teacher or students at other campuses during the course is good enough to go on with the course content and with interventions of all participants. It could be better.	The image of teacher or students at other campuses during the course has a high quality making it easy to go on with the course content and with interventions of all participants.

introduced. In (2015) the course didn't have the Erasmus Grant and it was run with success proving the sustainability of the course.

The course was developed with low-cost equipment so that everyone could participate without special TV-studios. All campuses had equipped one room with very high quality, although relatively low cost, material, which is very different from a closed TV circuit. This meant that the method, including the equipment, could be used in larger scale educational programs.

3.2 Rubrics used to measure competences

The competences presented in Table 3 should be strengthened and measured for the purpose to ensure that the students achieve a solid educational foundation and that they are capable of leading the way in innovation, emerging technologies, and in anticipating the welfare and safety needs of society. To evaluate the achieved learning outcome of the course, competences were measured and analysed. When, how and who to measure them are showed in Table 3.

The Communication Competence Rubric (Table 4) was fulfilled for each student during afternoon presentation and by all campuses in order to contrast results. At the end of the course, each campus should have evaluated all students at all campuses.

A second rubric (Table 5), the possibility to function in a multi-cultural audiovisual remote working environment rubric was also fulfilled, obtaining one measure per campus and per day. At the end of the course, each campus should complete the evaluation for all teachers, not only those that are teaching at their own campus.

4. Results and discussion

4.1 Communication competence

An analysis of variance has been done calculating the statistical parameters in order to know if there

Table 6. Results for CCF1 and CCF2

	CCF1					CCF2				
Campus	Count	Mean	Stnd. Error	Lower Limit	Upper Limit	Count	Mean	Stnd. Error	Lower Limit	Upper Limit
BME	21	3.51	0.20	3.24	3.79	21	2.85	0.19	2.59	3.11
ITU	56	3.17	0.12	3.00	3.34	56	2.48	0.11	2.32	2.64
KTH	61	3.29	0.15	3.13	3.46	61	2.89	0.11	2.74	3.04
OUSL	29	2.92	0.17	2.68	3.15	29	1.99	0.16	1.77	2.21
SUPELEC	42	2.97	0.14	2.77	3.17	42	2.55	0.13	2.36	2.73
TNT	21	3.43	0.20	3.15	3.70	21	3.13	0.19	2.87	3.39
UPM	31	2.83	0.16	2.0	3.06	31	2.77	0.15	2.55	2.98
Total	261	3.15				261	2.65			

Table 7. Results for CCF4 and CCF6

Campus	CCF4					CCF6				
	Count	Mean	Stnd. Error	Lower Limit	Upper Limit	Count	Mean	Stnd. Error	Lower Limit	Upper Limit
BME	14	3.37	0.26	3.01	3.73	21	3.2	0.20	2.92	3.48
ITU	54	2.45	0.13	2.27	2.64	56	2.68	0.12	2.51	2.86
KTH	57	3.07	0.13	2.90	3.25	61	3.49	0.12	3.33	3.66
OUSL	24	2.21	0.19	1.93	2.48	29	2.17	0.17	1.93	2.41
SUPELEC	42	2.64	0.15	2.43	2.84	42	2.71	0.14	2.51	2.91
TNT	19	3.24	0.22	2.93	3.55	21	3.13	0.20	2.85	3.41
UPM	28	2.76	0.18	2.51	3.02	31	2.82	0.17	2.59	3.05
Total	238	2.76				261	2.91			

are significant statistical differences for each communication competences between campus and between themselves. The factors are:

CCF1: The student clearly organizes the content of the presentation
CCF2: The student uses the adequate oral style to ease the instructors' understanding.
CCF3: The student appropriately uses the corporal communication language.
CCF4: The student uses graphics and other technical resources to effectively communicate the information.
CCF5: The student selects the appropriate set up for the presentation.
CCF6: The student has a fluid communication with the teacher using the technology available.

Results for CCF3 are not presented as the collaborative learning method ("remotely-located students with remotely-located campus coordinators/technical support/jury") did not allow to measure it properly from remote presence of teacher. In the same way, CCF5 was not measured as the set up for the presentation was limited by the communication system.

Table 6 and 7 present results for CCF1, CCF2, CCF4 and CCF6 factors in scale 1-4 as defined in the rubric (Table 4). Assessment was done by campus coordinator, technical support and jury (for final presentations).

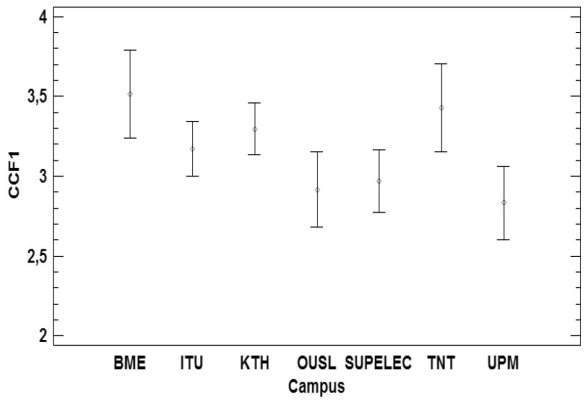

Fig. 1. Results for CCF1.

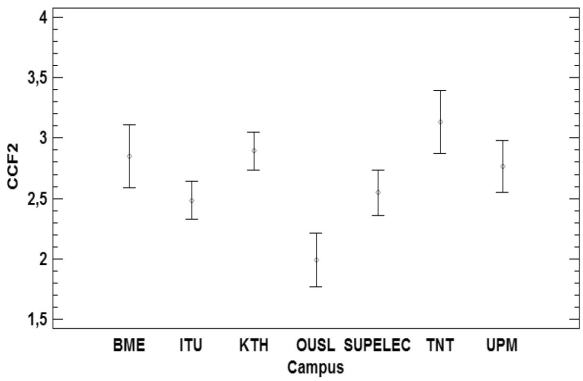

Fig. 2. Results for CCF2.

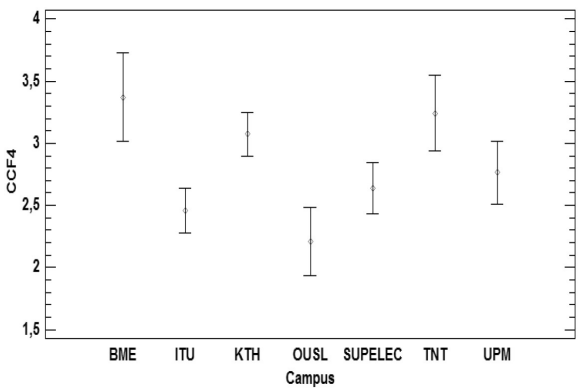

Fig. 3. Results for CCF4.

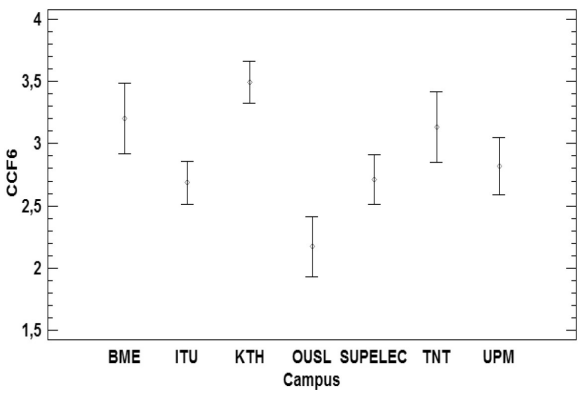

Fig. 4. Results for CCF6.

The P-values test was done for each factor of communication competence between campuses. Since the P-value is less than 0.05 in all cases (for CCF1 P-value is 0,039, for CCF2 P-value is 0.000, for CCF4 P-value is 0.001 and for CCF6 P-value is 0,000), the campus factor has a statistically significant effect on the different communication competences at the 95% confidence level. In general, results show that students had a satisfactory or excellent performance for all factors of communication competence. By campuses, as we can see on the different Figures (Figs. 1, 2, 3 and 4), OUSL's students have the worst performance in these competences, followed by ITU and SUPELEC. In the case of OUSL, this could be due to the existing problems with the collaborative software tool during the whole course.

Table 8. Global results for communication competence (all students and all campuses)

CFC	Count	Mean	Stnd. Error	Lower Limit	Upper Limit
CCF1	261	3.15	0.06	3.06	3.23
CCF2	261	2.65	0.06	2.57	2.73
CCF3	238	2.76	0.06	2.68	2.85
CCF4	261	2.91	0.06	2.83	2.30
Total	1021	2.87			

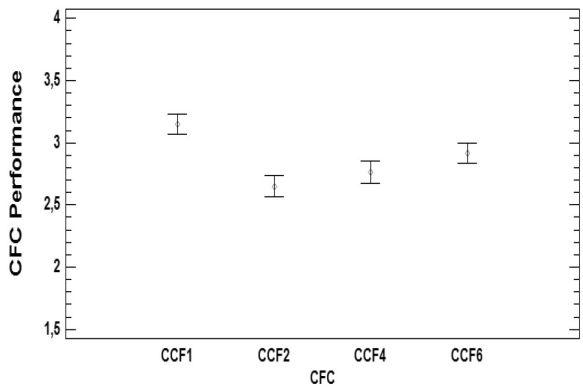

Fig. 5. Results for communication competences.

In addition, the P-value test was done for the results of the different communication competence factor. Since the P-value 0,000 (less than 0,05), this factor has a statistically significant effect on the results at 95% confidence level. Factor 2 (CCF2: The student uses the adequate oral style to ease the instructors' understanding), Factor 4 (CCF4: The student uses graphics and other technical resources to effectively communicate the information) and Factor 6 (CCF6: The student has a fluid communication with teacher using the technology available) are those that should be improved by students, especially Factor 2 and 4 (Table 8 and Fig. 5).

4.2 Possibility to function in a multi-cultural audiovisual remote working environment

In this case, factor measuring the student and teacher possibility to function in a multi-cultural audiovisual remote working environment were done by the technical support and campus coordinators.

For teachers, the factors are:

ARWECFT1: The teacher uses the audiovisual remote working on an interactive way to get students to participate at different campuses.

ARWECFT2: The technology is used properly to facilitate remote learning: the sound has high quality.

ARWECFT3: The technology is used properly to facilitate remote learning: the image of teacher or students at other campuses has high quality.

Results (Table 9, Figs. 6, 7 and 8) show that the teachers at UPM were the ones who used the audiovisual remote, in the best possible way in order to get students to participate at different campuses, having an excellent performance. Teachers in KTH and BME also had a satisfactory performance while teachers at ITU, SUPELEC and UTN had problems to use it and need to improve their performance. Regarding the sound quality, BME and KTH had good sound while the other

Table 9. Results for remote working environment for teachers

Campus	ARWECFT1	Stnd.Error	ARWECFT2	Stnd.Error	ARWECFT3	Stnd.Error
BME	2.6	0.85	3.1	0.14	0.9	0.14
ITU	1.2	1.13	1.6	0.57	2.9	0.14
KTH	3.0	1.41	3.6	0.57	3.3	0.42
SUPELEC	1.4	0.85	2.3	0.99	2.9	0.14
UPM	3.6	0.57	2.1	1.27	2.9	0.14
UTN	1.2	1.13	1.6	0.57	2.9	0.14
Total	2.16667	1.25	2.38333	0.96	2.63333	0.84

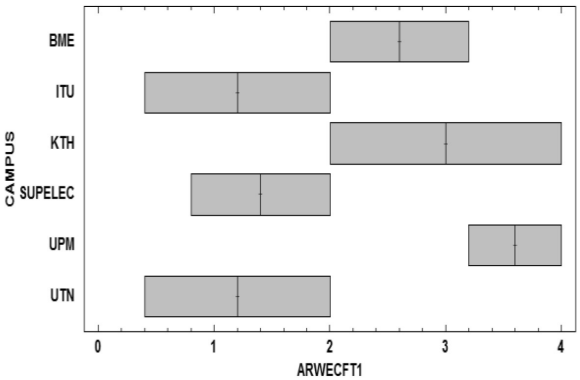

Fig. 6. Results for ARWECFT1.

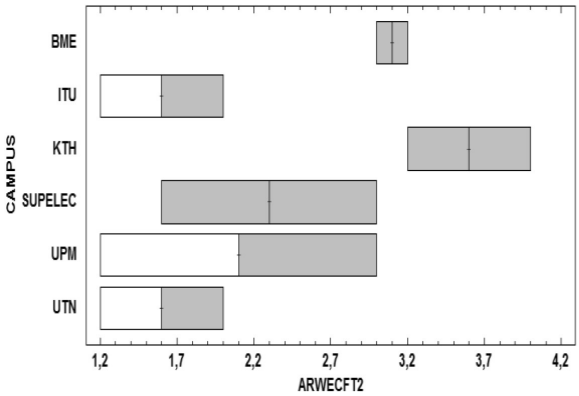

Fig. 7. Results for ARWECFT2.

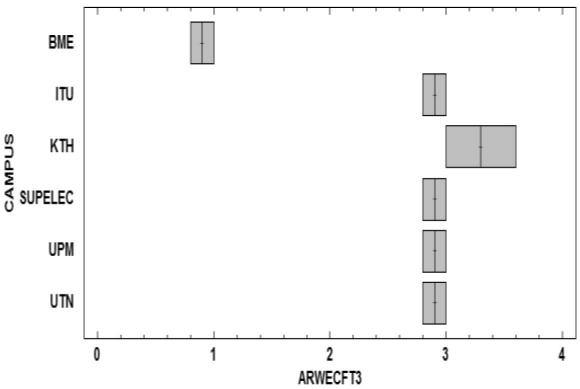

Fig. 8. Results for ARWECFT3.

campuses had some problems with the sound. In the case of the image quality, all campuses were successful in this area except BME.

Table 10. Results for remote working environment for students

	ARWECFS1	ARWECFS2
Count	107	126
Mean	0.6	0.6
Stnd.Error	0.71	0.82
Lower Limit	0.4	0.4
Upper limit	4.0	4.0

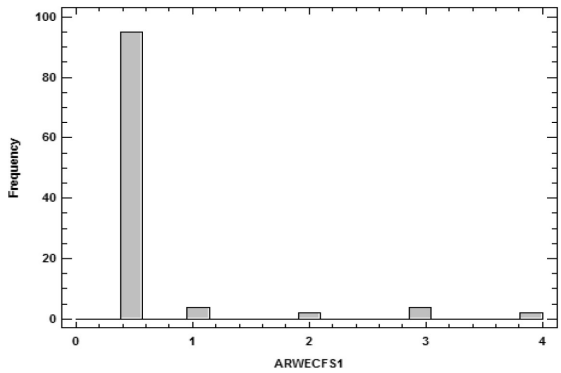

Fig. 9. Results for ARWECFS1.

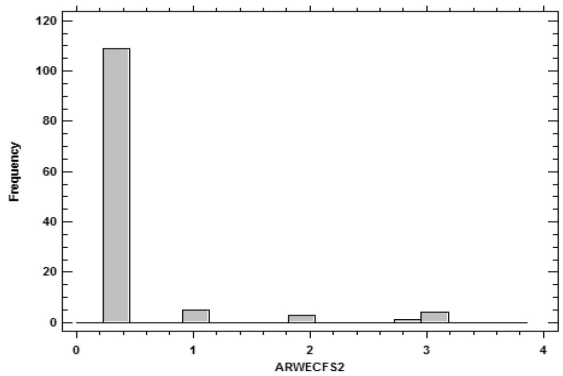

Fig. 10. Results for ARWECFS2.

For students, the factors are:

ARWECF-S1: The student participates actively during the class even if the professor is teaching in another campus.

ARWECF-S2: The students really interact with each other "over the remote boundaries".

Results (Table 10) show that students had real problems to function in a multi-cultural audiovisual remote working environment, both to participate

actively during the class even if the professor is teaching in another campus and to interact with each other "over the remote boundaries". In Figures 9 and 10 we can see that few of them, a minority, had a good performance on these factors, but the majority had an unsatisfactory performance.

5. Conclusions

During the development of this experience, rubrics have been used to measure the competence in communication and possibility to function in a multi-cultural remote learning environment between both students and professors in an international context. This is an innovative experience using PBL methodology and a new way for measuring this teaching-learning context.

The results show that students had a satisfactory or excellent performance for all factors of communication competence. Using audiovisual remote working was not the same at all campuses. The experience allowed participants to learn between themselves, improving the use of this technology when needed.

Students had real problems to function in a multicultural audiovisual remote working environment, both to participate actively during the class even if the professor is teaching in another campus and to interact with each other "over the remote boundaries". A few of them, a minority, had a good performance on these factors, but the majority had an unsatisfactory performance.

In spite of these difficulties, the experience allowed students all over the world to participate in the experience. In addition, students from a University in Sri Lanka could join, follow and participate during the course, which would not have been possible in a conventional teaching-learning way before. Considering the topics of the course, their contribution was of high interest giving different point of view helping to strength the ability for analysis and critical thinking.

Considering conclusions, authors propose recommendations for future courses:

- Coordinators should make sure that the technical equipment works properly to avoid problems of sound and image that were detected.
- It is necessary to look for new strategies to increase student participation over the remote boundaries.
- Regarding communication skills, results were pretty good in general. Nevertheless, it would be positive to work with students on oral presentation styles, for example, giving them some indications on how to improve this area, during the first session of the course.

These results encourage professors to improve the experience taking into account the improvement opportunities detected. All the partners gave a very satisfactory assessment of the experience contributing in different ways, all of them important to make this course a truly knowledgeable and experience exchange.

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