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EXPERIENCES IN COLLABORATIVE LEARNING

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Cooperative learning is a paradigm of collaboration aimed to reach a common goal. The trend of using social networks and social media to deliver and exchange knowledge leads us to believe that collaboration skills must be strongly promoted to empower users to learn with and from each other to support the educational challenges of this century. In this paper we discuss the primary needs of a modern educational system and we present the ETC*plus* project, a model of cooperation that has as its primary focus students' cooperation in an academic environment. Two distinct experiments involving cooperative learning with two international universities are discussed. The first describes a system in an environment that is left to evolve autonomously. The second presents a system in a controlled environment that uses an accelerator to speed the learning process. The process of collaboration was built on a shared platform. Students' feedback shows that cooperative learning produces better results when consonance

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and resonance are reached. The paper discusses the pros and cons of the ETC*plus* project.

1 Introduction

One current compelling discussion among public officials and citizens, as well as in academia and industry, is how to deal with the complex problems created by globalization. This includes education, environmental protection, water resources management, reduction of pollution, production of clean energy on a large scale, and how to provide advanced health care while world population continues to rapidly grow, especially in developing nations. No individual has all the answers, but collectively many people may develop ideas to provide answers for such complex problems. In this spirit, in 2009 IBM invited hundreds of universities and research centers to participate in the creation of a Smarter Planet Jam University. On that occasion 50% of participants came from North America, 25% from Asia and 20% from Europe. Only 2% came from Africa, and 0.5% from Latin America.

The Smarter Planet University project was the first Jam IBM community of people that involved many university students (75% university students, 12% professors and researchers). A community of people accustomed to tools that support globalization (i.e. Web, social networking, etc.) could provide future solutions to global problems. The Jammers have been asked to answer complex problems, such as: "*On a smarter planet, what are the interdisciplinary skills that students require in order to compete in an increasingly interconnected, intelligent, and instrumented market?*". 80% of students expressed the desire for an updated educational system. The message is clear - in a world in a socio-political and economic crisis, the students desire a better world.

Here are some of the students request and our observations:

1. *The students request an educational system morphed to modern times that puts the students at the center of the educational process and let them choose when, what, and how to study.*
   <u>Observation</u>: The majority of universities in the world suffer from isolation that does not let them keep up with the speed of globalization. In a speech, Nicola Meek, Chief Executive of "Secondary Futures" in New Zealand, says that "*The actual sequential educational system which lets young adults to progress from elementary school up to college is becoming an obsolete method in the learning process development. This is because the educational system is not able to keep up with a world that becomes more complex and changes rapidly.*" While some universities are adapting well to the changing needs of the world, others are late due to inefficiency, and/or attachment to old learning systems.

2. *The students are fascinated by geographically distributed team projects, as proven by the autonomous projects kindled in the social network. The students also recognize that in education such projects will be guided by a teacher whose role is more that of a coach rather than a traditional teacher.*
   Observation: The new students' generation has seen the growth of online courses and uses social networks as tools for the free expression. This sends a clear message to academia: optimize services and create digital information available to everyone in a safe, secure manner. This has the advantage of offering educational material that can be consolidated, permitting more efficient administration.

3. *The students expressed the need for a university that during their study allows them to evaluate potential success they can reach in a particular area of study.*
   Observation: Worldwide industry is moving away from traditional processes, from top-down development model to services. Do the universities guarantee that students will succeed in this changing workplace?

4. *The students understand that there is a need for the formation of T-people, e.g. by combining computer science and engineering with business and communication competences and skills, and by fostering creativity.*
   Observation: T-people have an in-depth knowledge of some disciplines and a broader knowledge of others. These are the people that industry has identified as having the proper modern competences. Unfortunately today's educational system is still far from providing this type of competences. Most of the curricula focus only on "in-depth" knowledge of a specific discipline, leaving students unprepared to compete in a global market based mostly on services, human interaction and global virtual teams. Team projects should be the preferred model not only for interdisciplinary formation but also to guarantee a mix of business skills, knowledge of the technologies, and personal creativity. T-people will prosper in a model combining critical thinking, creativity and innovation with leadership, understanding of global processes and digital knowledge.

5. *The students recognize the need for collaboration between companies, academia and students, and suggest that students build working relationships with future employers.*
   Observation: The advantages of this collaboration are two: one is formation of T-people; the other is the continuous update of academic curricula

to incorporate fresh contents. We believe that this collaboration will produce innovation in the learning system.

These challenges are recognized by the ACM community which in (ACM, 2014) gives the changes in Computer Science curriculum required to provide the new fundamental skills and knowledge that computing students must possess. One of the fundamental skills that students must acquire is ability to collaborate. All previous observations can benefit from collaborative learning. The boom in social networks leads us to believe that there is a need for collaboration and teaching techniques aligned with rapid innovation that guides the learning experience, and helps form the desired individuals (Maglajlic, 2012). E-learning has shown great potential. The growth of massively open online courses (MOOCs) is providing alternative avenues of learning for those looking for self-paced learning and for those in search less expensive education (Vardi-Moshe, 2012). However, those courses require self-discipline, and cooperative projects at a distance require high collaboration abilities.

These observations have motivated the creation of the ETC*plus* project, a model of cooperation that has, as primary focus, student cooperation in an academic environment. In this paper we describe the experimental work performed in the ETC*plus* project, and the results and lessons learned from the experience. This work does not want to do an analysis of the collaborative learning model in terms of pedagogy rather wants to discuss the experiments conducted in three years of collaboration within the project and the lessons learned. In Section 2 we discuss cooperative learning and introduce the project. In Section 3 we present the state of art in cooperative learning. In Section 4 a hybrid model for cooperative learning is described with the role of governance in the community of discussed in section 5. In Section 6 we present experimental data obtained from two studies in collaborative learning. Evaluation and discussion of the results are given in Section 7. Finally, in Section 8 conclusions and future research are presented.

2 Cooperative Learning and the ETC*plus* Project

Cooperative learning is a paradigm of collaboration aimed at a common goal. It differs from *individual learning* or *competitive learning* where individuals must reach the same goal but compete rather than cooperating. Competitive learning generates a winner and many losers - a point that is not as significant as gaining knowledge over time. Cooperative learning is designed to support and reinforce knowledge acquisition as students learn from each other, and learning is faster (Bermeio, 2005). The approach is student-centered since the teacher is moved to a more peripheral role such as a facilitator, coach, or counselor. In this new role, the teacher can better communicate with students who see the teacher as an active participant in learning. The students learn from the teacher's behavior and mimic him/her while tutoring other participants. This boosts and speeds the overall learning process of the community.

A Community of Practice (CoP) is defined in (Wenger, 1998; 2000) as "a network of people who share a common interest in a specific area of knowledge (and) are willing to work and learn together over a period of time to develop and share that knowledge". Many CoPs are born from the spontaneous cooperation generated by social networks. Other CoPs have been generated by academic or industrial research projects. Small CoPs in an academic environment can be used to stimulate collaboration and improve learning. The ETC*plus* project (Maresca *et al.*, 2012) extends the learning paradigm of the ETC[1] (Enforcing Team Cooperation) project (Coccoli *et al.*, 2011; Coccoli *et al.*, 2010) and is supported by IBM's Academic Initiative. It fosters the creation of CoPs on a joint platform (IBM Jazz-Hub platform) and uses a process model that encourages dynamicity among all participating instructors who accept and incorporate knowledge from other communities. The coordination model and steps for creation of a learning environment in ETC*plus* generate an *open innovation network* which fosters the creation of an "intelligent" community. To validate the model, a CoP that links two universities, one in Italy, one in the US, over two courses has been created. The students cooperated on projects and the results of this cooperation are used to validate the benefits of ETC*plus* and identify strengths and weaknesses of the model. The goal is to provide virtualization of an environment around an extended community for distance learning. The community offers coaches that help members in their work and that rev up the dynamicity of the learning process when it slows down.

3 Related works

Collaborative learning originates from the socialization process that involves individuals who, participate in communities of practices born around objectives and cooperate. Collaborative learning is supported by new technologies as shown by CSCW (Computer Supported Cooperative Work) systems which combine understanding of the way people work in groups with enabling technologies, services, and techniques.

Research in collaborative learning runs from creation of e-leaning communities and innovation networks to the pure technology used for learning. In (Thaw *et al.*, 2008) the authors introduce CoPE (Community of Practice Envi-

[1] ETC is a project supported by IBM in the area of Academic Initiative that received the IBM Academic Award 2011 http://www.ibm.com/developerworks/university/facultyawards/, was nominated IBM Best Practice 2011 at the IBM Innovate 2011, and received special mention among the worldwide academic institutions in http://www.sysmannews.com/SearchResult/35610.

ronment), a platform (and a philosophy) to democratize learning. CoPE extends an e-learning environment through introduction of mechanisms of democracy such as management of workflow of documents, voting rights, and so on. The environment is configured as an "open" innovation network as opposed to the "closed" innovation network described in (Hamburg, 2010). Another aspect of an innovation network is based on the management process. The authors in (Marcus *et al.*, 2011) address construction of an "adaptive" system in which a teacher can customize tutorials and provide feedback to students during training. This approach emphasizes the importance of feedback within a CoP by customizing interactions.

Another significant aspect of collaborative learning is the shift in focus from student-centric to teacher-centric. However aspects that consider teacher-teacher interaction or academic-industry interactions have also been considered. For example, in (Wegener & Leimeister, 2012) the authors propose a model of teacher-teacher interaction that contributes to the building of CoPs for the production of continuously updated shared educational resources. In (Kern *et al.*, 2007) the training experience of a team of engineering students is presented. The focus of this work is on an interdisciplinary approach that emphasizes industry needs. Particular attention is given to the skills that future engineers must have to collaborate and interact with other professionals to better compete at a global level. The work is based on the model designed by Johnson and then applied in the engineering field by Smith (Johnson *et al.*, 2007). While this model is highly cooperative, it does not seem to form the desired T-shaped people. The authors show the effectiveness of the CLOP (Cooperative Learning Observation Protocol) when applied to a CoP.

Another aspect of research in collaborative learning is represented by the tools used for collaboration and the collaboration achieved when they are effectively used in a distributed environment. Through the use of wikis, people can share cross-cultural knowledge via design patterns (Schadewitz & Zakaria, 2009). In several papers knowledge transmission and collaboration among people of different cultures are highlighted including how to measure the degree of cooperation reached in diverse projects (Hamidi & Baljko, 2012). These results reinforce that it is possible to spread knowledge through cooperation between people of different cultures, mentalities and characteristics. In the majority of cases collaboration has been performed using tools for the creation of wikis, forums, and media conferences. In-house tools have also been created. In this paper we have chosen to select a commercial collaboration tool, the IBM Jazz platform. Even though our experimentation was performed in academia, the ETC platform is not limited to a specific community but can be extended to any who wish to make cooperation its key tool of research.

Models of collaboration have also been devised. In (Arora & Goel, 2012) a set of existing models for software development is discussed and a taxonomy given. In (*Ibidem*) the foundations of groupware are also reported, i.e. the set of tools that support developers. Ellis et al. in (Ellis *et al.*, 1991) define groupware as "computer-based systems that support groups of people engaged in a common task (or goal) and that provide an interface to a shared environment".

Collaboration is starting to lead to the development of new academic curricula as shown in (Gluga *et al.*, 2013) which discusses the design of degree programs, so that the sequence of learning activities, topics, and assessments over three to five years give an effective progression in learning of generic skills, discipline-specific learning goals and accreditation competencies. Their system tackles this challenge, helping teachers define the curriculum, linking it to institutional goals. The same information is available to students. The system was validated across three different faculties, for a period of three years. The portal includes reporting and visualization tools.

Teamwork requires discussion and trust. Trust is gained through reputation earned during cooperation and represents an added value that must be protected in terms of privacy and must be legitimately obtained. The work in (Anwar & Greer, 2012) shows how reputation can be transmitted to others via an identity management system that protects personal information while maintaining anonymity. Discussion is a central part in project development, but the debate when forum are used can become confusing and difficult when it is necessary to let filter important posts. The research in (Abel *et al.,* 2010) shows a system of recommendations in an e-learning environment that extracts important posts. Measuring the level of cooperation achieved during collaboration is a difficult process. A solution is proposed in (Ebrahim, 2011) in which a fuzzy system of inference is used to evaluate cooperation between students in an e-learning session.

Research results developed in the area of cloud computing and e-learning are analyzed in (Ewuzie & Usoro, 2012). An application of cloud computing is given in (He & Vue, 2012) which presents the construction of an e-learning cloud for sharing e-learning resources. In (Cao, 2003) the influence of the social network position of a trainee/trainer (tutor) in e-learning is investigated. An algorithm that performs the best matching between trainees and their tutors within a social network is used to improve the learning outcome.

4 Consonance and Resonance: an Hybrid Model for Cooperative Learning Teaching Methodologies

To achieve excellence in knowledge acquisition and production, cooperative learning should be merged with proper teaching methodologies. The question is: "*While teaching software development skills, are there techniques that can* *improve cooperation and quality of material produced by students?*" To answer this question we look at existing teaching software development methodologies. For example, can an agile teaching methodology (a methodology that involves students in an agile process) be used to speed up the learning process and the quality of deliverables? In agile development, good time management together with agile techniques is a recipe for success. Can we expect that good time management together with teaching in an agile way is a recipe for success of a course? The word agile refers to something that is fast to adapt, extremely flexible and quick in movement (Cao, 2003). Research has discovered efficient tools and methods for software development that produce software systems that are more flexible while maintaining high quality. Agile software development is geared towards satisfaction of the customer (which becomes the success of the team or company), while agile teaching process is geared towards satisfaction of the teacher's requirements which coincide with the success of the student.

The agile methodology works very well when a high level of coordination and cooperation has been reached. This is typical of an industrial environment. Unfortunately, most students have a minimal experience of coordination and cooperation. The classroom, then, must be quickly transformed into a group that forms a strongly connected network. A group can be seen as a viable system that is able to evolve and modify its structure due to internal or external modification agents (Maresca *et al.*, 2012). A viable system is "*a set of components interacting with each other in a coordinated manner, directed and guided toward the pursuit of an end*" (Vardi Moshe, 2012).

In order to achieve desired objectives, it is necessary that relationships inside the network can be qualified in terms of consonance and/or resonance. In music, consonance (from the Latin *cum+sonare* "to sound together with") gives the listener the impression of stability and repose contrary to the impression of tension or clash obtained in dissonance. In an orchestra, its members must reach a level of consonance before playing together. Then this consonance must be transformed in a resonance that lets the music vibrate and permeate the air. In a similar way, we believe that a working team must reach a level of consonance before their work starts to resonate. The concept of consonance in a team refers to the potential compatibility of the participants, while that of resonance actualizes the concept of consonance by making possible an efficient collaboration. The ability of an individual to interact with others is characterized by the action of two forces (Golinelli, 2011): consonance - fundamental to reach a state of harmony; competition - that creates resistance to collaboration. However the law of Requisite Variety (Ashby, 1956) states that variety absorbs variety, i.e. all the different varieties, even though in opposition, will eventually align. Therefore, a group is comparable to a viable system whose varieties must be aligned. A Viable System Approach (VSA) (Barile & Polese, 2010) offers interpretation schemes useful for analyzing and governing the structure of relationships and the process of interactions of systems. In particular, for the alignment of the varieties of individuals, we suggest checking the consonance at the level of categorical values of each individual.

According to the model of categorical variety (Barile, 2009; Barile & Saviano, 2011), the knowledge that identifies an effective system is constituted above all of deeply rooted values, beliefs and opinions, as well as cognitive schemas. Common or harmonic values act as facilitators of interaction between different actors. Consonant categorical values generate a gravitational center which attracts the shared goal(s).

Therefore, we propose a hybrid model that integrates consonance and resonance in an agile methodology. The methodology must be accompanied by appropriate tools. A good balance between these components provides an effective agile teaching process. The crucial point is represented by collaboration which requires the existence of consonance and resonance within the team to be effective. The factors that influence cooperative development are:

1. *communication*, which implies the existence of consonance and resonance, and aims to "harmonize" the team before their "performance"
2. *coordination*, i.e. the set of activities required to conduct the work in an autonomous way, obtained by dividing the work in tasks or subtasks, by planning the meeting of verification, by structuring a plan, etc.
3. *cooperation*, i.e. the set of activities the team will perform in order to reach the goal.

5 The Role of Governance

The process of coordination can be either autonomous or guided. In an academic environment, the process of governance is the responsibility of the instructor. When a hybrid model is used there is less need for a role of government because the alignment between the actors naturally emerges. The question is: "*How can individuals who lack cooperative learning experiences, possess different values, different patterns, and different cognitive and behavioral models, interact effectively as nodes in a networking organization aimed at achieving shared goals?*"

Obviously this will occur through a process of spontaneous governance that starts from the bottom and leaves to its participants the management of tools and mechanisms of collaboration. The teacher, as a coach, must help the teams identify points of consonance and teach them to reach the level of resonance in the fastest way. By working on elements that stimulate the concepts of consonance and resonance the teacher is able to inject some accelerators in the groups' development: accelerators that can speed up the learning and increase the quality of the product.

In the classroom, teachers and students face some of the same difficulties that software engineers and customers face while developing software with an agile process. So using the metaphor of agile software development, we see that small teams of engineers (often in pairs) quickly produce deliverables that satisfy customers' needs. In a teaching and learning environment students, as engineers, are required to produce deliverables (i.e. solutions to problems, small programs, etc.) to satisfy the teacher's request. In reality the teacher plays both the role of the customer (as the person to be satisfied) and the role of the expert or coach of the team (i.e. guides the students in the process). As the customer the teacher provides requirements to the students who interact with the teacher for clarifications, specifications, and modifications. Then the students design, implement, and delivered the solution to the teacher. In some cases, the teacher returns the material to the students with feedback that forces the students to adapt the material to create new deliverables. As in the case of software development, high quality of deliverables is expected and adaptability increases the chance to produce the deliverable on deadline.

6 Experimental Data

This work does not want to do an analysis of the collaborative learning model in terms of pedagogy rather wants to present some experiments and discuss the lessons learned from them. The first experiment involves students to whom a limited time was given (two days). However very precise instructions are provided and the students are free to choose any communication and/or interaction tool. The second experiment is much longer (3 months) and involves multilingual students from different universities. The experiment uses a process model for the development of cooperative learning. An intense coaching activity and accelerators for the improvements of the group activities is given. The groups are periodically observed and controlled. In summary, the first experiment is in free evolution, while the second is in constrained and accelerated evolution.

6.1 The first experiment: the Refactoring Study

The "*Refactoring Study*" involved 18 Computer Science students from a Software Engineering course paired to form small VSAs. The goal was to observe group cooperation, the consonance and resonance of the VSAs, and the quality of work in the groups. Stress factors were added, such as physical distance and time constraints. Software tools were allowed to support cooperative process and design.

The experiment incorporates two core principles of eXtreme Programming (an agile software development technique): pair programming, and refactoring. The selection of these techniques was dictated by the goal to achieve team cooperation and products of high quality. Refactoring (Fowler, 1999) is the process of improving the design of code without changing functionality, thus generating *clean code* (Martin, 2009) that is maintainable and extensible and injects quality in the final product. Pair programming is a process where two programmers, a driver and a navigator, communicate and synergistically work towards a solution. The driver controls the keyboard and focuses on coding while the navigator helps the driver and focuses on strategic architectural issues (Williams and Kessler, 2003; Wray, 2010). Pair programming helps build better software (Coman *et al.*, 2008) and injects communication, collaboration, and hopefully speed during production.

The 9 VSA pairs of the participating students had never applied refactoring before. Over 48 hours the students were asked to develop the code of a system which simulates a video store that keeps track of rented movies by customers and answer 8 questions. The code consisted of 5 classes, 2 test cases, a makefile and a readme file. Out of the 8 questions, 5 required specific refactoring of the code. of refactoring asked. Additional questions required code comprehension and reverse engineering application. See Table 1 for the typology of the questions; details are omitted for simplicity.

Table 1
THE REFACTORING STUDY

	Questions
Q1	Draw an initial UML class diagram
Q2	Write a unit test
Q3	Extract method refactoring
Q4	Replace temp with query refactoring-
Q5	Move method refactoring
Q6	Replace type code with state/strategy refactoring-I
Q7	Replace type code with state/strategy refactoring-II
Q8	Draw the final UML class diagram from the code

The communication was challenged by splitting each pair in two different classrooms to simulate distribution, with communication only through virtual applications. To stimulate collaboration, the following information was given:

- Two days before the study the students were informed of the study, of their partner, and that they would be asked to share thoughts, code, diagrams, etc. during the activity. They were also invited to identify any communication tool they wanted to use.

- On the day of the study the students had a 3 minute face-to-face meeting before being divided in separate classrooms. In the meeting the students had to agree on the tools of communications and mean of cooperation.

The team participants were asked to alternate the role of the navigator and the driver as pair programming requires. This requirement was used to share responsibilities within the group. At the beginning of the study a set of tools and applications including a common repository was made available for those groups that either did not reach an agreement or that needed additional support; however no one was forced to use any of the listed applications.

All the teams returned the entire assignment within the given time with 62.5% of the teams scoring an A/A- grade, 37.5% a B-/B/B+ grade. Of the 62.5%, 32.5 completed the study with >95% accuracy, while the remaining 25% were in the range 90-95. One team did not complete question 7, and 1 team did not complete question 8. Considering that nearly 50% of the groups stated in the post-questionnaire that more time should have been allotted to complete the work, this result is highly encouraging.

As expected, the students agreed on communications tools they were most familiar with. The type of application and the percentage of each application is shown in Fig. 1. The degree of difficulty (see Fig. 2) perceived by each student increases with the exception of questions 5 and 8. In particular the difficulty of question 2 is perceived by 56% of the students (an increase of 31% with respect to question 1) and represents the sharpest difference in degree of difficulty among the questions. This means that the students had to face a distinct increase of difficulty at the beginning of the process. Previous studies (Guercio & Maresca, 2013) have identified an important problem that arises in pair activities: there is a communication gap at the beginning of the working activity which may or may not be filled. When this gap is not filled the result is chaos and frustration of the team participants and the quality suffers. This gap adds to the difficulties intrinsic to the problem. The work of reducing these obstacles before a working session may help to improve results and minimize failure obtained when consonance and resonance is not reached.

Fig. 1 - Collaboration tools chosen by the students

An effective system of cooperation is composed of deeply rooted values, beliefs and opinions, as well as cognitive and interpretation schemas. Common values in people who cooperate, act as facilitators of interaction. Consonant categorical values generate a gravitational center that attracts to the shared goal. In these cases the alignment between the participating actors naturally emerges and has been found in the majority of groups. Discordant categorical values generate "cognitive traps", i.e. places where the VSA gives up due to obstacles to learning. These obstacles are caused by widespread opinions, prejudices, syndromes (e.g. "*prima-donna*" syndrome, too many details, etc.) and they do not allow the consonance and resonance. All these factors contribute to the time required to produce the product and its quality. The average time per question graph s shows that each VSA spent an amount of time proportional to the degree of difficulty of the question which means that the students reached a consonance soon. We believe that this has been helped by the freedom of choice given since the students chose applications they were familiar with.

Qualitative information was extracted from a post questionnaire and from the individual answers to the exercise. For those teams who completed the work it was found that there was at least one individual in these teams who was well versed in programming. However, even the individuals who thought were at a higher ability level confessed that their partner really helped them in achieving their goal faster. One student mentioned: "*It was an interesting project, and it definitely made me feel like I need to learn more about C++. I understood exactly what the questions were asking me to do but when it came to the coding part my partner was much more efficient than I was at that point.*"

One group complained about distance as a barrier to the work activity and they struggled to reach consonance and they thought that the work would have gone more smoothly if we could have worked together face to face.

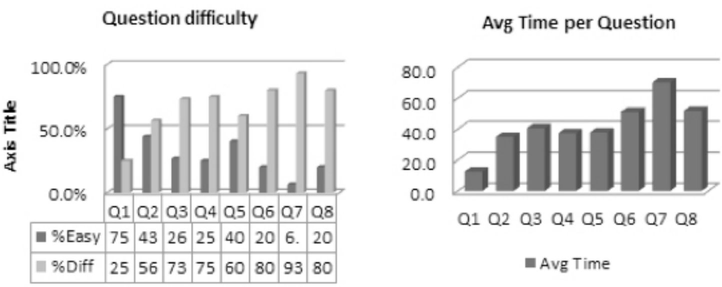

Fig. 2 - Degree of difficulty per question and average time spent per question

The VSAs found the time constraint too tight as these comments show:

"*This assignment is much too difficult to finish in the time allotted. A week would have been much more sufficient to allow for technical issues and other problems that groups may have..*"; "*I thought this project would of worked better if we had more time, or that didn't take away so much of my time …*"; "*More time for the assignment would have made things easier*".

A benefit that emerges from this study is that students get to know their fellow students better. For example one student mentioned that he didn't know his partner too well but he found him a very competent partner.

6.2 The Second Experiment: An Academic Cooperation

The second experiment performed creates a virtual CoP that joins two academic institutions who share common goals: the Faculty of Engineering of the University of Naples "Federico II" (UNFII), and the Dept. of Computer Science of Kent State University at Stark, Ohio, USA (KSU). The Cooperation Process Model (CPM) used to create the academic CoP is depicted in Fig. 3. The model requires the identification of:

1. participating entities;
2. areas that may benefit from cooperative learning and the analysis of common objectives while maintaining constraints required by each participant;
3. a set of cooperative learning activities of practice that achieve the common objectives;
4. resources required for deployment of the process;
5. a Work Breakdown Structure (WBS) which plans the distribution of the organizational tasks.

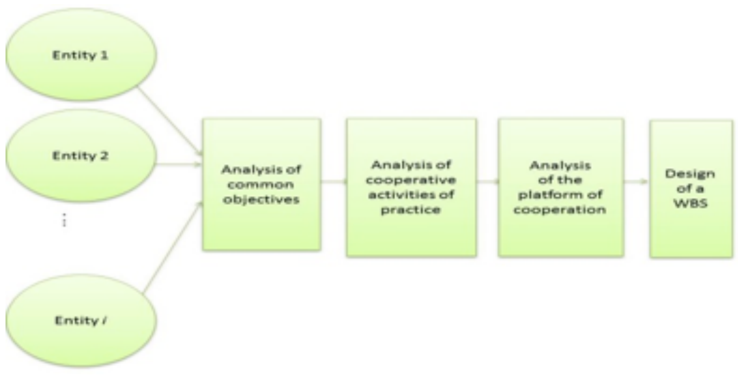

Fig. 3 - The ETC*plus* Cooperation Process Model (CPM)

During the *Analysis of Common Objectives* two programming courses were chosen: *Programming I* at UNFII and *Computer Science II* at KSU. The learning goals and objectives were clearly highlighted in this stage. Since the selected courses were delivered face-to-face, the entities were required to preserve the characteristics of a traditional course. However they were free to incorporate distance learning activities to foster cooperative learning. In this phase the policies, rules and regulations required by each entity, and synchronization of activities were analyzed. For example courses were held in the fall semester, but the participating universities started and ended at different time. A synchronization plan beneficial to both institutions was devised. When this analysis phase was concluded, the entities started identifying teaching activities to boost students learning and to empower them with tools to operate as independent learners, cooperating team leaders, and tutors for other students. Such activities included the deployment of the course material, the virtual laboratory, and the students' assessments. The collaborative activities identified were: programming camps, discussions on a competition, and general team related activities, such as forums, group assignments, etc.

During *Analysis of Cooperative Activities* a set of activities for the design and organization of the course were identified. This included the generation of a joint syllabus, the installation, testing and revision plan of the common platform, the set-up plan of the shared virtual laboratory, and the layout of the tentative outline. Additional customized activities were inserted in the course by each institution to meet their needs. Deadlines were identified for each course with the constraint to maintain joint deadlines for joint activities. The activities of cooperation identified in the previous stage were designed. For example, the students of KSU were selected to tutor the students of UNIFII since their course started 4 weeks before the UNIFII course.

During *Analysis of the Platform of Cooperation* the IBM Rational Jazz platform was selected. This platform provides the ability to handle the whole project in a cooperative fashion, to share documentation and to align modifications performed during the development process.

The course laboratory was designed on top of this platform and was accessible either via native client, browser, or Eclipse plugin. A screenshot of the laboratory access via Eclipse is shown in Fig 4. Moodle was also used as a content management system.

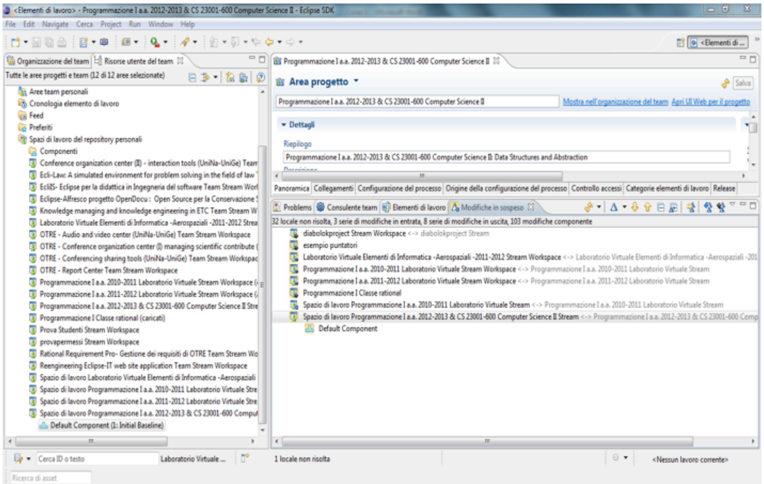

Fig. 4 - The Eclipse ETC*plus* virtual laboratory

Finally, the WBS for the application was completed and the work breakdown for the preparation of the teaching material, the setup of the virtual laboratory, and preparation of the documentation of the virtual laboratory established. All activities were jointly designed and required extensive collaboration of the participating entities.

The experiment between UNFII and KSU lasted a semester and involved around 100 at UNFII and 20 at KSU. In addition to producing tangible deliverables, it was an opportunity for the evaluation of the training process delivered. Evaluation was performed at the end of the experiment via questionnaire. The answers were mapped to a 5 value metric scale used to measure the results and analyze them objectively. Figure 5 shows the survey consisting of 22 questions. Table II shows the correspondence between a feature of the process and its corresponding question(s). There are many points of interest to test in a complex experiment as this one, however we kept the number of questions around 20 to encourage truthful answers, and avoid survey dismissal that often occurs when large requests are submitted.

Fig. 6 represents each question with its mean value on a star at 22 branches of a Kiviat diagram. This diagram is useful to highlight the strengths vs. weaknesses of our project. The results of the survey have also been plotted on a graph that shows the standard deviation, mean and median of each question. The standard deviation, with its index of dispersion around an expected value, is used to represent the precision with which the measurement has been carried out. Low values indicate high precision.

LEGEND: wks=weeks

1. Did you have previous experiences of Communities of Learning? *0: Nothing 1: A little 2: Enough 3: More than enough 4: A Lot*	2. After the experiment did you learn something new about designing and implementing software in a collaborative environment? *0: Nothing 1: A little 2: Enough 3: More than enough 4: A Lot*
3. Overall, how much did you learn in the ETC experience? *0: Nothing 1: A little 2: Enough 3: More than enough 4: A Lot*	4. What is the level of cooperation that you achieved in your group? *0: No cooperation 1: A little 2: Enough 3: More than enough 4: A Lot*
5. What did you learn about software development in cooperation? *0: Nothing 1: A little 2: Enough 3: More than enough 4: A Lot*	6. Did you encounter language barriers in your group? *0: Not at all 1: Very little 2: Some 3: Quite a bit 4: A Lot*
7. How clear where the instructions of the project you had to solve in the ETC experiment? *0:Totally insufficient 1:Below Sufficient 2:Average 3:Good 4:Excellent*	8. During the experiment you had to use some software applications such as Eclipse and the Jazz platform. What was the personal amount required to learn the above mentioned applications? *0: I do not know 1: ≥ 2 months 2: 1-2 months 3: 3-4 wks 4: 1-2 wks*
9. What was the personal amount of time required to learn only the Eclipse application? *0: I do not know 1: ≥ 2 months 2: 1-2 months 3: 3-4 wks 4: 1-2 wks*	10. What was the personal amount of time required to learn only the Jazz application? *0: I do not know 1: ≥ 2 months 2: 1-2 months 3: 3-4 wks 4: 1-2 wks*
11. How much would you evaluate the quality of the material provided to instruct you on the installation and use of the Eclipse application (i.e. video, files, etc.)? *0:Totally insufficient 1:Below Sufficient 2:Average 3:Good 4:Excellent*	12. How much would you evaluate the quantity of the material provided to instruct you on the installation and use of the Eclipse application (i.e. video, files, etc.)? *0:Totally insufficient 1:Below Sufficient 2: Average 3:Good 4:Excellent*
13. How much would you evaluate the quality material provided to instruct you on the installation and use of the Jazz application (i.e. video, files, etc.)? *0:Totally insufficient 1:Below Sufficient 2:Average 3:Good 4:Excellent*	14. How much would you evaluate the quantity of the material provided to instruct you on the installation and use of the Jazz application (i.e. video, files, etc.)? *0:Totally insufficient 1:Below Sufficient 2:Average 3:Good 4:Excellent*
15. How much would you evaluate the organization and the use of the material and the tools offered in Moodle? *0:Totally insufficient 1:Below Sufficient 2:Average 3:Good 4:Excellent*	16. Besides the material provided by the teacher, how much personal search did you need to understand the use of the software used in the ETC experiment? *0: Nothing 1: A little 2: Enough 3: More than enough 4: A Lot*
17. How quick was the help provided to solve the software issues that you have encountered? *0:Totally insufficient 1:Below Sufficient 2:Average 3:Good 4:Excellent*	18. How would you evaluate the whole ETC experiment? *0:Totally insufficient 1:Below Sufficient 2:Average 3:Good 4:Excellent*
19. How useful, in your opinion, is this type of experiment in a course of CS 2? *0: Not useful at all 1: A little 2: Enough 3: More than enough 4: A Lot*	20. Did the ETC experiment satisfy your expectations? *0: No 1: A little 2: Enough 3: More than enough 4: A Lot*
21. Did you know how to use Eclipse before this course? *Yes/ No*	22. Did you know how to use the Jazz application before this course? *Yes/ No*

Fig. 5 - The ETCpus experience survey

Table 2
THE REFACTORING STUDY

Feature(s)	Questions
1. ETC*plus* preprocess - precondition assessment	1
2. ETC*plus* postprocess - learning assessment	2-3
3. ETC*plus* - cooperation assessment	4-5
4. ETC*plus* - cooperation barriers assessment	6-7
5. ETC*plus* - time spent assessment	8-10
6. ETC*plus* - quality of educational material & organization	11-16
7. ETC*plus* - process & tools evaluation	17-23

The first question, with its mean value of 1.88 in Fig. 7, shows that the groups had little experience of e-learning environment before the project. This may be an advantage, since our students sample can be seen as a "blank slate". The learning process is assessed using questions 2 and 3. The graph of Fig. 6 shows that the students were sufficiently satisfied in acquiring knowledge on software design and implementation using the ETC*plus* paradigm. The third feature corresponding to questions 4 and 5 evaluates the cooperation between international students and shows a nearly sufficient level of cooperation.

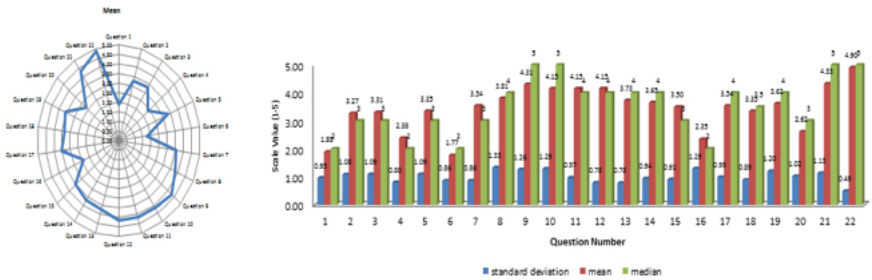

Fig. 6 - The Kiviat graph and the assessment graph of the ETC*plus* process

The fourth feature corresponding to questions 6 and 7 is used to detect barriers encountered during the cooperation phase. The mean value of 1.77 for questions 6 shows that the students of different languages, with different teachers, etc., naturally have barriers of communication. The language is one of the main barriers and this problem was detected especially by the Italian students who had to interact with Americans in their mother tongue. On the other side, from question 7 we observe that the instructions given were very clear and this has allowed them to better approach the problems and compensate in part for the language barrier. Two additional fundamental aspects of this project were the time spent by students to participate in the ETC*plus* project, and the way they strategically used the time to acquire knowledge in the context of their cultural improvement. The time dedicated to acquire the know-how required was between 1 and 2 months. This is not a very long time if we consider the fact that the majority of the participating students worked either full or part time. The quality of the teaching material used as well as the quality of the organization perceived is a key point and it reported the best result (see questions 11-16) and full approval of those who participated in the project.

Finally, we observe that the students appreciated the many efforts made to connect different and distant universities for the development of a joint course. However the same experiment received some complaints from the fact that some collaborative activities were time consuming. This, in fact, required them to be engaged in additional activities such as conference call, video call, and so on. At the end of the survey the students had the opportunity to provide suggestions to incorporate in future project developments. The quality of the work developed by the groups is the tangible aspect of the success of the process development. The *programming project* assigned to each group requested the development of an application of an ATM teller machine. We were struck by the high quality of the code produced in such a short period of time.

7 The GQM Approach for the Evaluation of the Process of Collaboration in ETCplus

The central focus of these two experiments is not architecture but collaboration. The first experiment shows a spontaneous collaboration. The second experiment builds collaboration around common objectives, it facilitates them with the use of accelerators and it evaluates them objectively. The process of collaboration has been measured by using the GQM metric. The GQM (Goal/Question/Metrics) (Basili & Caldiera, 1994; Seaman & Zelkowitz, 2006; Basili, 1994) is a process for the quantization of goals during the measurement of a product or a process. The measurement model has three levels (see Fig. 7):

- Conceptual (Goal)
- Operational (Question)
- Quantity (Metrics)

The GQM model has a top-down hierarchical architecture. The root of a hierarchy is a Goal, which is divided into branches which converge in the Questions that characterize the goal. From the Questions the Metrics are produced. Each metric can be used to respond to more than one Question from the same Goal, even though it may assume different values according to the point of view.

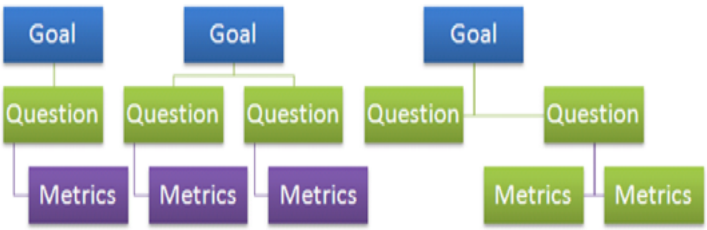

Fig. 7 - Hierarchical Structure of the GQM

To produce an objective evaluation of the different points of view we apply the GQM approach to the *programming project* assigned during the ETC*plus* project. The GQM process goes through several phases. The first phase is the Prestudy. It characterizes the domain of measurement by identifying essential information such as preconditions and constraints, strategic objectives and existing experiences, etc. Most of the students are sophomores and do not have any experience of cooperative development. They also do not have experience with the tools (Eclipse and Jazz) used in the project. The time difference may add to poor synchronization. The second phase consists in the identification of the goals, i.e. the definition of a set of goals for the improvement of the development process. A priority is assigned to each goal according to its relevance and impact in the strategy of the organization.

The objectives that we propose to reach target specifically the collaborative software development. In particular we consider the following three goals:

- Goal 1: *The improvement of the use of collaborative tools for collaborative development;*
- Goal 2: *The improvement of the efficiency of collaboration among members of the team for collaborative development;*
- Goal 3: *The improvement of efficiency of the development in the context of collaborative development.*

After the initial phases of Prestudy and Goals Identification, the process enters the operational phase which consists in the formulation of the Questions used to describe the identified Goals. This phase is followed by the production of the GQM Plan. A GQM Plan is a structured document in which each objective is associated with a set of metrics whose values, once detected, provide a measure of the degree to which the objective has been reached. Subsequently, a Measurement Plan is developed. Metrics correspond to the *Variation Factors*, associated with the *Quality Focus* of each Goal identified.

The last phase is the collection and validation of the data. The data collected for the measurement of the objectives must be in agreement with the previously developed GQM and Measurement Plans. In the ETC*plus* project, some data have been collected using interviews of development team members. Other data have been collected automatically by the platform used for cooperative development which allows us to track and plot the progress of the cooperative. The collected data of interest are then analyzed to assess the degree of correspondence between the value obtained and the expected value. This process is repeated for each Goal. The values associated with each data for each goal are: a detected value, a metric, a weight, a response (relative to the value detected) and an expected value. Table III summarizes the results of the GQM analysis of the ETC*plus* project. For simplicity the table shows the detected value, the expected value, and the percentage of correspondence achieved for each goal. The percentage of correspondence indicates a sufficient/good value but it is not very high for each goal. The lowest value is for Goal 2. This means that the collaboration reached by the students within the ETC*plus* project is sufficient but must be improved. A slightly better result is obtained in reaching Goal 3. This means that also here there is room for improvement in the code development. A better result instead is reached in the use of the collaboration tools. The lack of experience of those tools has partially been compensated by the large quantity of high quality support material provided by the coordinators to the students.

Table 3
THE REFACTORING STUDY

Goals	Detected Value	Expected Value	Percentage of correspondence
Goal 1	68	93	73.1
Goal 2	52	84	61.9
Goal 3	59	87	67.8

Documentation should be produced during the process. All the documents, such as the Goal Selection Sheet, the Goal Template, the Abstraction Sheet and the Measurement Plan, must be collected for a future reuse of the process.

Goal 2 represents the natural glue between the two experiments. Although in the first experiment metrics for the measurement of the collaboration were not defined, we empirically observe that the system (i.e. the CoP) was left free to evolve, it reached a balance in collaboration and produced results as any viable system. Wherever the level of cooperation achieved was low the objectives were not fully reached. Consequently the results of that group were not satisfactory if compared to other groups. The second experiment instead generated a hybrid system. The second system shows improvements, even though we detect room for further improvements in the results of Table III for goal G2.

The authors believe that we have to work hard on the consonance of mini-viable systems formed by the groups to increase collaboration. Consider that the sample population had students of different languages and universities who were expected to resonate without having previous communication. Resonance is the result of a collaboration process that has evolved. This is similar to when you take a group of musicians. Individually they are very good; however they still need to rehearse before reaching that that level of collaboration that lets them produce a great performance. We believe it is important that the participants get to know each other first (albeit virtually) before working together.

Conclusions and Future Research

In this paper we discuss cooperative learning and the issued of the educational system. The process of collaboration was designed on top of a shared platform. This system realizes the concept of an *innovative university* (Maresca *et al.*, 2012), an *open innovative network* of people where:

- students learn from people or students of other universities or industry;
- relations among students and future employers are stimulated;

- T-shaped people are formed;
- instructors are helped and supported in their endeavors;
- collaboration is fostered to contribute in the maintenance and update of the curricula

The project was well received and the overall quality of the artifact was very satisfactory; however additional time might have improved some results that were produced under stress. In a future work we would like to emphasize the quality of the training process by measuring the process directly from the platform used during the experiment.

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