Design and Engineering International Collaborative Projects: A state of art

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ABSTRACT

Due to the Globalization and the industrial development world wide, Engineering Collaborative projects have never been more important and the necessity of improving the processes used among them, neither.
The language barrier is a mayor downfall for the success of any international project, and even though English is universally spoken, technical terminology is not well known. So here is where collaborative platforms become an essential tool, and the standardization of the procedures as well. In order to compare the competencies of the parties involved, so it becomes noted the areas of expertise of each country considering their culture and education models, it is necessary to evaluate and measure the individual and group skills of the participants, this information can be used in case of further projects as well it will give an idea of the strengths and weaknesses of each specific area in the selected country. After processing such information the results will give a clear view of the state of the actual situation on the matter; how to improve/develop an application or platform for efficient collaborative projects, what are the weak points or the competencies that are needed to improve to be better prepared for international projects, this are just few of the many applications that this kind of study can throw and it gives an idea to the universities of how to mold their programs and overall education to be at a competitive international level.

Keywords: Engineering and Design, International Collaborative Projects, Competencies, 20/20 Engineer, Engineering Education.

1. INTRODUCTION

Collaborative Design on Engineering projects in the present are being one of the preferred cases of studies in the last 10 years in the engineering education, due to its similarities to the work group environment in the industry companies, and the benefits well known of this way of teaching, like the problem solving and group skills developed by the students involve in this activities, this way of teaching students grows fast in popularity inside university faculties. Deficiencies also encountered in present students in higher education like critical thinking have also made collaborative projects a good alternative in order to meet the goals set by each university of what kind of competencies their students should have after graduating, in sight of perusing

a masters or doctoral degree or just as regular industry workers. Recent research has shown that collaborative projects give the opportunity to the students to apply knowledge learned previously and also to retain concepts better than in the traditional classroom environment, this psychological analysis of cognitive learning processes that involves effective learning as well is one of the key factors to explain how and why collaborative projects serve better than compared to the traditional way of teaching, to help students become better professional respecting what each university considers that this would be. What this paper is going to show is at what is the stage of research in collaborative design on engineering projects are, what are the measurements already found by previous researchers, what are the key processes identified in group collaboration projects, what are the key aspects on international collaborations, with this referring to cultural differences and ethnicities and what other models have been found to evaluate and measure this activities in other to future improvements and to design better collaborative experiences.

2. PROBLEMS DURING NOW DAYS COLLABORATIVE PROJECTS

In the latest findings done by researchers about cognitive learning, collaborative projects have been praised as ideal to the creation of long lasting knowledge to learners from all fields of expertise (cooper et al., 1990) this applied to higher education, without saying that in any other kinds of levels of education this approach won work, this paper will only focus on higher education specifically in the fields of engineering and design. As it is stated in the early mention findings collaborative projects maybe a better alternative than traditional teaching methods in order to build competencies for the engineer of this days, but not only this, but the kind of skills to work in a globalized world where engineers will have to interact with other professionals and colleagues from different parts of the world and with different cultures (Kelly, D. S., et al., 2005) It is necessary that this types of competencies are develop in order to facilitate the success of future engineers in the modern world

But this is what unveils what are the present strategies used among this types of projects, they have already been catalogued to be effective cognitive learning activities (Koschmann et al., 2005) but are they really been carried out with effectiveness and are they really giving good results? That's one of the questions that this paper plans to address, and with this, sharing the state of the art strategies and techniques that are being used presently within faculties and universities involving engineering and design. This without acknowledging that much research still to be made in this field and also giving the importance deserved in the field of psychology to help to improve this kinds of projects in the early future and overall teaching methods.

First we are going to start talking about of the lack of formal structure or hierarchy (Finger & Gelman et al., 2006) which addresses a problem that relating to the way groups are assembled or put tougher by the facilitator or sometimes even by the students themselves when this is the case. This kind of problem of students not having a formal structure or that the teams are chosen by them to be group of peers leads to a lack of responsibility distribution which at he end will only difficult the assessments of each students contribution to the final outcome and final result, which will lead into a uneven unfair mark to the members of the team because they will all gain the same mark but with different efforts and contributions. This will also have to do with the fact that if there is a lack of formal structure the smartest individual of the group or with the more developed social skills will come up with all the answers and will dictate them to the whole group (Collazos et al., 2007), and this poses a problem regarding the meaning of even doing the collaborative project at the beginning if there wasn't going to be any collaboration at all, rather a dictatorship.

3. STATE OF THE ART TOOLS AND STRATEGIES

It is very important to be informed in what are the state of the art tools used in collaborative projects, this will help to design a better collaborative experience for the students and will also help to not repeat mistakes already done in the past, for this it is important to state what it has worked in the past and what is working in the present. Its important to keep in mind that this alternatives still are being tested and for that they are still a work in progress.

Co-Construction as mention before is one of the key factors to keep in mind in a collaborative activity it allows students to interact successfully and build on each other's knowledge, this is the successful activity of knowledge building and problem solving between individuals (Finger & Gelman et al., 2006).

Personality Type Testing: To have successful collaborative experiences it is important to have a clear view of how the teams of students are going to be assembled, when is done incorrectly different or oppose personalities might collide and make the activity less harmonious and less productive (the keirsey temperament sorter 2 "Keirsey 1998"), (Myers-Briggs Personality test "Myers and Briggs, 1975), personality test are powerful tools to prevent that.

CSCL: Computer Supported Collaborative Learning, as it was mention in the beginning of this paper are a set of tools that allow teachers and educators to improve their methodologies of teaching and at the same time improve the assessments of projects (Francescato & Porcelli et al., 2005)

CCC: Cross Cultural Collaboration is basically only applied in collaborative project that require international participants from different parts of the world, this not mean that they have to be physically in different locations, but this will enrich the experience by being expose to different environments but at the same time have to work together for a common goal (Nguyen-Ngoc, Law et al., 2010).

PBL: Project Base Learning, this is a tool aimed to the new methodologies of teaching which are focus in to change the traditional ways in to experiences that emphasize student learning rather than instructor teaching, and this can play a key role in the successful development of a "Global Engineer", this methodology changes the way of how teaching has been conceived in the past years where the teacher is the focus of attention and the student is forced to take a passive role in his learning (Savage & Vanasupa et al., 2007)

Proactive Learners: Talking about the new ways of teaching it also important to talk about the roles and how they change into the new methods environment Proactive Learners are people who take the initiative in learning, they learn and retain more than people who sit at the feet of teachers **passively** waiting to be taught (**reactive learners**), this of course is what teachers should be aiming to imprint in their students, to take their knowledge as something that belongs to them (Savage & Vanasupa et al., 2007)

Communication Diary: The monitoring and assessment of the projects are essential in the success of the activity this is what will prevent problems in the future, improve future experiences and will look after the learning processes of the students, the Communication Diary will allow students to keep track of the communications with their facilitators as well as peers, at the end this will help to reflect and analyze how the activity took place (Nguyen-Ngoc, Law et al., 2010).

Assessment and type of assessments: Assessment is by far the best way for tutors or facilitators to intervene in a collaborative activity, that's why is very important to have a clear sense of what assessment mean and what types of assessments exist.

Individual Assessment: It means to review and support each individual's progress, and the goal here is to keep track individually of every person involve in the project (Diaz & Brown et al., 2010).
Collective Assessment: Collective Assessment is more involve with the benefit of the team and its united work, that's why its aim is to review and support group work, and to foster the learning community. (Diaz & Brown et al., 2010).
Formative Assessment: Monitor work on a regular basis, spell out frequency or timing for instructor monitoring as part of the course of project expectations. Asserting needs for additional resources, guidance**,** revisions.

Determine whether all participants are contributing and whether the timeline is being observed (Diaz & Brown et al., 2010).
Summative Assessment: Compare results with goals and objectives, identify best practices, give fair grades (Diaz & Brown et al., 2010).
Individual Assessment: Takes place when the learner provides his or own assessment of performance and contributions to the collaborations, individuals can be asked to reflect on their experiences as part of a collaborative group team (Diaz & Brown et al., 2010).
Instructor Assessment: The instructor assesses individual achievement in the context of a collaborative activity (Diaz & Brown et al., 2010).
External Assessment: When the collaborative project or activity extends beyond the classroom, what this means is that the teacher or tutor takes the assessment into a non formal space(the classroom) to get a better result on his assessment.

Attributes of Effective Learning Processes: Since in this paper is mention the importance of cognitive learning and the main difference it has from traditional believed learning, that is more drawn into memory retention, it is very important to keep in mind the attributes necessary in order to achieve effective learning (Alavi et al., 1994).

Active Learning and Construction of knowledge
Cooperation and Teamwork in Learning
Learning Via Problem Solving

GDSS: Group Decision Support Systems are also a great tool to use in collaborative activities; they enhance learning by facilitating active construction and development of emergent knowledge (Alavi et al., 1994). It is fundamental that teachers, tutors and educators use the tools they think fit for the project at hand, they will help the experience and overall success of the project, it is also important to know that not all tools will apply to all the projects but the teacher in charge of the activity has to decide which ones to use.

Reflective Week: To really understand what the new research are showing about learning and understanding, there must be clear that reflection is essential for cognitive learning to take place a Reflective Practice (Finger & Gelman et al., 2006) is often advised to be immerse inside the collaborative activity and the **Reflective Week** is a good alternative to this and the main idea is based around a team questionnaire which encourage students to reflect on the collaborative processes (Breslin & Grierson et al., 2007).

Collaborative E-Learning: E-Learning being one of the must upcoming educational tools, couldn't left out the advantages of collaborative projects that's why collaborative E-Learning will help by constructing knowledge, negotiating meanings and or solving problems throughout mutual engagement of two or more learners coordinated effort using internet and electronic communications for some or all their interactions (Diaz & Brown et al., 2010), as it was mention before in this paper the importance of using technology in teaching relies strictly on the way the technology is put to use, E-Learning with their wide set of aligned tools is a very good example in to how collaborative projects can be carried out when physical interaction is not available due to distance constraints.

Important Indicators: Researchers Johnson and Johnson stated that in order to fin some indicators for evaluating or assessing a collaborative project, the following activities had to be carried out (Johnson, D., Johnson,R.: Learning together and Alone, cooperation, competition and Individualization., 1998)

Use of strategies: Applying strategies are to capture the ability of the group members to generate communication and consistently apply a strategy to jointly solve a problem (Collazos et al., 2007).
Intra-Group Cooperation: Includes measures related to the requirements of every player from her peers to reach her partial goals when acting as a coordinator, if each group member is able to understand how her task is related

to the global team goals then everyone can anticipate her actions, requiring less coordination efforts (Collazos et al., 2007).

Success Criteria Review: Monitoring and assessment can be tricky, it could be hard and unclear to place the contributions of each participants in order to give them the deserved mark, for this the Success Criteria Review is very helpful because it measures the degree of individual involvement of the group members in reviewing boundaries guidelines and roles during the group activity (Collazos et al., 2007).

Monitoring performance of the group: To fully understand this indicator first its important to separate its two main action Monitoring and Performance; Monitoring is to oversee if the group maintains the chosen strategies to solve the problem keeping focused on the goals and the success criteria and Performance is about quality, how good is the result of collaborative works, time (total time elapsed, time while working), work (total amount of work done "Baeza-Yates and Pinolli", overall this indicator provides and understanding on the fulfillment of the group (Collazos et al., 2007).

Types of Collaboration: It is indispensable that the types of collaboration a clear in order to understand better how the collaboration within the working teams take place. Now its important to take notice that the success of each type of collaboration is dependent to the types of personalities and that's why personality tests are so important to be carried out before the assembling of a working group, both type of collaborations can be successful if the working groups are put together carefully.

Democratic Collaboration: There is no clear leader and when students were too polite or of such similar ability, they were declined to criticize in depth (Tucker & Rollo et al., 2006).

Oligarchic collaboration: Group driven by one or two high achievers collaborators. Not only this groups often produce the most accomplish and innovative designs, but they usually result in a positive learning environment for everyone (Tucker & Rollo et al., 2006).

Understanding Collaboration Processes: this is fundamental and its understanding is basically intrinsic to the success of any activity related to collaboration between individuals, the mutual engagement of participants in a coordinated effort to solve a problem together is what this activities are based upon (Collazos et al., 2007).

4. DESIGNING A COLLABORATIVE EXPERIENCE

Some of the early mentioned tools can become handy at the time of designing a collaborative project, but its also important to keep in mind that in favor of designing a fully successful activity there are more things to contemplate. The most important parts of a collaborative experience are the designing of the experience itself and the assessment or evaluation of the experience at the end, without doing a good job on both of them the risk of not having a thriving project at all, so we wish that in this paper it becomes clear the comprehension of what its important in both cases starting from the design and then moving to the assessments.

The Designer of a collaborative learning activity needs therefore to design an activity that requires collaboration (Collazos et al., 2007), in spite of being the one of the objectives of collaborative projects this key factor is commonly overlook and taken for granted and this frequently leads to problems as that the smartest individual comes up with all the answers and just dictates them to the group.

The aim of collaborative activities is not just to produce a good group product (Lambert et al., 2003) by whatever means but also to ensure that every member contributes effectively and is involved in producing the group outcome, this is the crucial core of a collaborative project most assessments are only focus on the outcome of the teamwork but not what is behind this outcome and so this doesn't tell much about how the work was put together and if the students interact correctly in favor of contributing for a final product, teachers and educators need to pay more attention to the process and not just the end result because the final goal of this projects are to educate students and by only paying attention to results they are leaving the biggest part of learning out, which is the coming up with the answers the actual process of learning.

According to Johnson and Johnson, five essential elements that are necessary to allow for true team efforts are (Kelly, D. S., et al., 2005):

Positive Interdependence
Individual accountability
Face-to-face Interaction
Social Skills
Group Processing

The designation of roles within the group teams and the overall experience is very important, having clear what is the individual responsibility in this process makes success to be achieved easer and in a more natural way, in other words if every individual knows his/her roles no ones would step on each others ground and problems originated by this type of bad structure organization can be easily be avoided if they are well adjourned in the beginning of the experience and initials design so design roles such as : **Speaker, Facilitator Recorder, Executor** and **Observer**(Collazos et al., 2007) really come in handy and useful during the collaborative experience but in order to do this correctly it is important to define all the roles in this activities as detail enough so there is no blind spots:

The role of the individual in the group is understanding the group itself (Collazos et al., 2007).
The Teachers role as guide not as an assessor (Hargreaves et al., 2007).
A good **supervisor** can successfully integrate different areas of knowledge and ensure that students can work toward a common goal (Sclater & Grierson et al., 2001).
Student's roles are to reflect on their learning both individually and socially (Collazos et al., 2007).

As a surprise for many students performance is appreciatively higher for group design projects compared with individual projects, and that this improve performances in enhance further when collaborative skills are taught as part of the group project (Tucker & Rollo et al., 2006), what this means is that maybe it is time that the teaching of collaborative skills being a non traditional set of competencies, are introduced in collaborative courses, they could be assembled in a way that and introduction into collaborative behavior is thought before the actual initiation of the collaborative project, there could be many options to apply this in to the courses and educators should find the best ways to do the merger, and also evaluate their effectiveness so further knowledge about the same topic can be developed. One thing is clear students need help to develop the communication skills essential for effective collaboration, and that this help must come from tutors who have time and moreover training to carefully teach and even model skills (Tucker & Rollo et al., 2006), and the responsibility for the training of the educators come from the academic institution themselves, they have to take the matter at hand and develop adequate training programs that can foster this kind of skills in teachers as well, it is important that the educators themselves are well training in the matters of collaboration and problem solving so they can asses correctly their students.

5. LATEST FINDINGS ON ASSESSING COLLABORATIVE PROJECTS

First of all it is important to remark that the assessment of a collaborative project is a crucial activity that must be done correctly and with the information necessary to actually create meaning out of the assessment and not just do it for doing in it, there is a clear necessity of developing assessment procedures and tools to properly evaluate the development of professional skills into engineering students (Esparragoza & Rodriguez et al., 2010), and for this we reiterate the importance of being trained and prepared for completing this kind of task in a way it helps improve the experience and the leanings of students.

One evaluation method that has been used successfully and has potential for the development of team skills while decreasing the likely hood of **social loafing** is the utilization of **peer evaluations** (Kelly, D. S., et al., 2005).

Peer evaluations have been proven to be very effective in stimulating team unity, it seems that peer evaluation could be the fairest way to give a mark or grade the members of a work team, team members are the best evaluators of their teammates (Kelly, D. S., et al., 2005), because even thought the tutor or facilitator does a good job at monitoring team interactions, the only ones who know how was the team environment and what was the contributions of each member to the final outcome are the peers for that a the only ones capable of giving a fair mark are them, and also being themselves the ones who are grading each other drives them to be more helpful between each other because they know there mark depends on their behavior and performance inside the team, using this reasoning **peer evaluations** have big advantages to normal tutor evaluations and assessments.

The validity of the assessments it also a very important matter to consider, the only worth of an assessment is that an assessment is actually helpful for any purpose concerning the evaluation and the activity itself, assessments are likely to have a high degree of validity if the following conditions are met (Hargreaves et al., 2007):

The assessment for learning actually leads for further learning of a kind that is consistent with other visual values
The form and content of the assessment for learning encourages valuable learning

Validity in assessment is crucially about making appropriate articulation between the assessment and the construct it samples (Hargreaves et al., 2007).

It is also very important to use the adequate tools for assessing successfully, assessment can become an avenue of meaningful communication (Diaz & Brown et al., 2010), so its crucial to have a clear understanding of what assessing is and what it will bring to your project, a collaborative assessment for learning is unlikely to take the for od measurement resulting in leveling or grading although it might include some elements of measurements or be accompanied by measurements (Hargreaves et al., 2007).

Finally it is imperative that the **collaboration learning phases** are well defined, this is heart of nay collaborative project or activity and it will enhance the planning and design taking it to a more concrete level and overall ti will help to understand how the activity will be executed

Pre Process: Coordination and sketches, coordination and strategy definition on activities, design the contents specify the group sizes, arrange the groups, arrange the room, distribute the material, design the roles, specify the rules, define success criteria, define the decided behavior. The facilitator does all these activities (Collazos et al., 2007), (Collazos et al., 2002).
In-Process: Preform by the **learners**, its important to evaluate this stage, cooperative work done by the **group members,** application of strategies; positive interdependence of the goal, motivation between pairs, aid to learn. Intra group cooperation, prove the success criteria, monitoring, provide help from facilitator and peers, intervene in case of problems, self evaluation of the group, feedback (Collazos et al., 2007), (Collazos et al., 2002).
Post Process: Evaluation of the activities, work evaluation, inspect success criteria, present the activity closure, evaluate the quality of the learning, all of this accomplish entirely by the facilitator (Collazos et al., 2007), (Collazos et al., 2002).

6. CONCLUSIONS

All through this paper its been mention the importance of the importance of collaborative projects within education and the development of competencies and skills necessary to become a successful engineer in the modern world, traditional teaching is falling to develop this kind of abilities and it is urgent that all teachers that are involve in design and engineering relate fields get aware of this and stop fearing the change, academic

institutions such as the universities also need to take responsibility in the matter, they can leave teachers alone and pretend that they change there mental view of teaching from one day to the other without understanding the concepts and the full capacities of this new ways of teaching, training most be provided by the universities and **E-Competencies** must be thought in to teachers, its important that teachers have the capacities to use the tools that are now being provided by the modern technology, internet and all its magnitude has brought a new handful of possibilities that can be introduced into the classroom and outside the classroom as well, and educators can neglect the fact that they are there and that they can be helpful, technology is here to help if its used correctly. It is also important to fully understand the gains and the losses of collaborative projects due that they can not be applied to teach any kind of subject, it is fundamental to be able to make an accurate decision into realize which kind of subjects candy be thought by this method.

Group Process Gains (Alavi et al., 1994)

A group as a whole generate more information and alternatives compared to the average group member
Groups are more effective and objective in evaluation and error detection tasks
Working in a group may motivate the individual ember to preform better

Group Process Losses (Alavi et al., 1994)

Member participation in the group process is fragmented, i. e., group members should take turns on speaking
One or few individual embers may dominate group discussions and monopolize the groups time
Fear of negative evaluation (evaluation apprehension) cause members to withdraw and avoid participating in the group discussions
Higher volumes of information generated during the group process creates a condition of "information overload" for individual members

Now the losses and the gains are not alone the indicators that will dictate the decision of including a collaborative project in a subject, they are merely informative and they become useful in the design of the activity when for example the **Group Process losses** can be use to try to tackle this inside the base design of the activity, still its important to keep them in mind.

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